

Developing Synoptic Human Threat Indices for Assessing the Ecological Integrity of Freshwater Ecosystems

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Wetland Program Development Grant
and Missouri DNR 319 Grant



Missouri
Department of
Natural Resources



Meeting Overview

- Project overview
- Progress since last meeting
- Introduce Preliminary Human Threat Index
- Threat Index Discussion

Project Overview Outline

- Background
- Goal
- Data & Methods
- Creating “Threat Index”
- Resulting Products
- Utility

Funding Sources

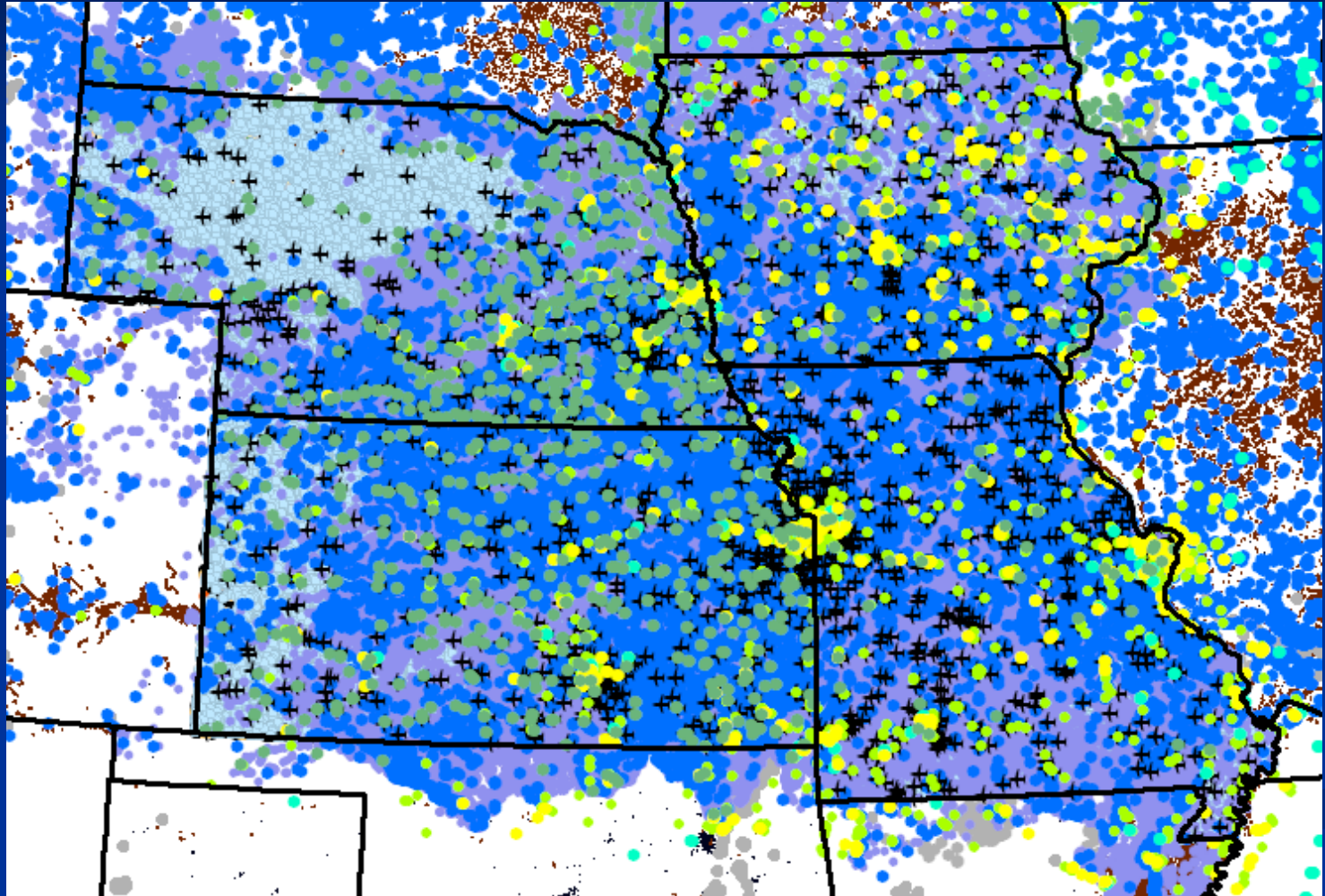
- Iowa, Kansas, and Nebraska portion
 - EPA Wetlands Development Grant
- Missouri portion
 - U.S. Environmental Protection Agency Region VII, through the Missouri Department of Natural Resources, has provided partial funding for this project Under Section 319 of the Clean Water Act

Background / Key Issues

- Resource managers don't necessarily manage the resource, but manage human activities that impact resource quality
- Common questions of resource managers:
 - What factors threaten the ecological integrity of a stream of interest?
 - What threat is most pervasive?
 - Where are these threats within the network or watershed?
- Answering these questions helps us target specific threats at specific locations

Potential Human Threats

Land Use
Impervious
Railroads
Channelized Streams
Airports
Toxic Releases
Superfund
Oil and Gas Wells
Mines
Landfills
Hazardous Waste
Sites
Waste Water Treatment
Leaking Underground
Tanks
CAFOs
Dams
Roads
Headwater Impoundments
Certified Wells

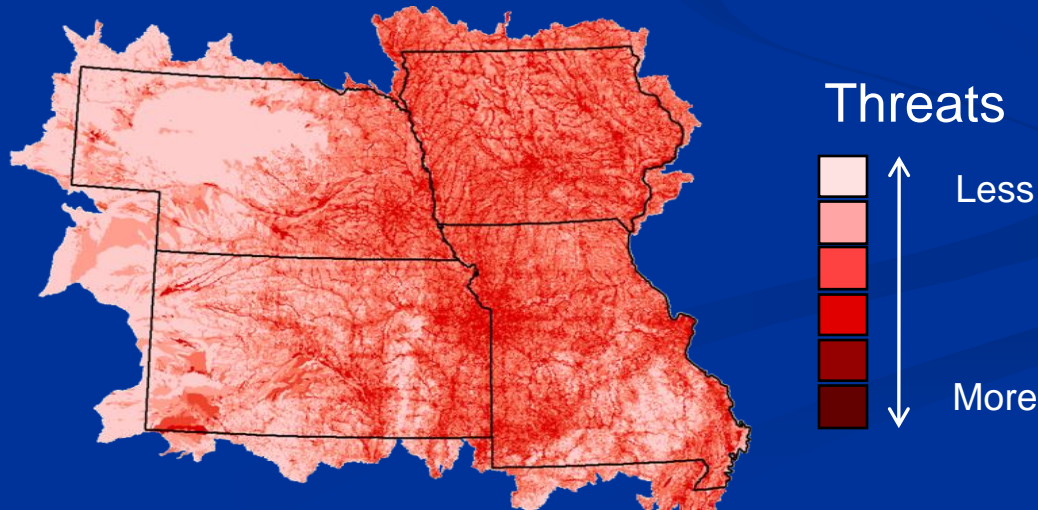


What we are trying to accomplish?

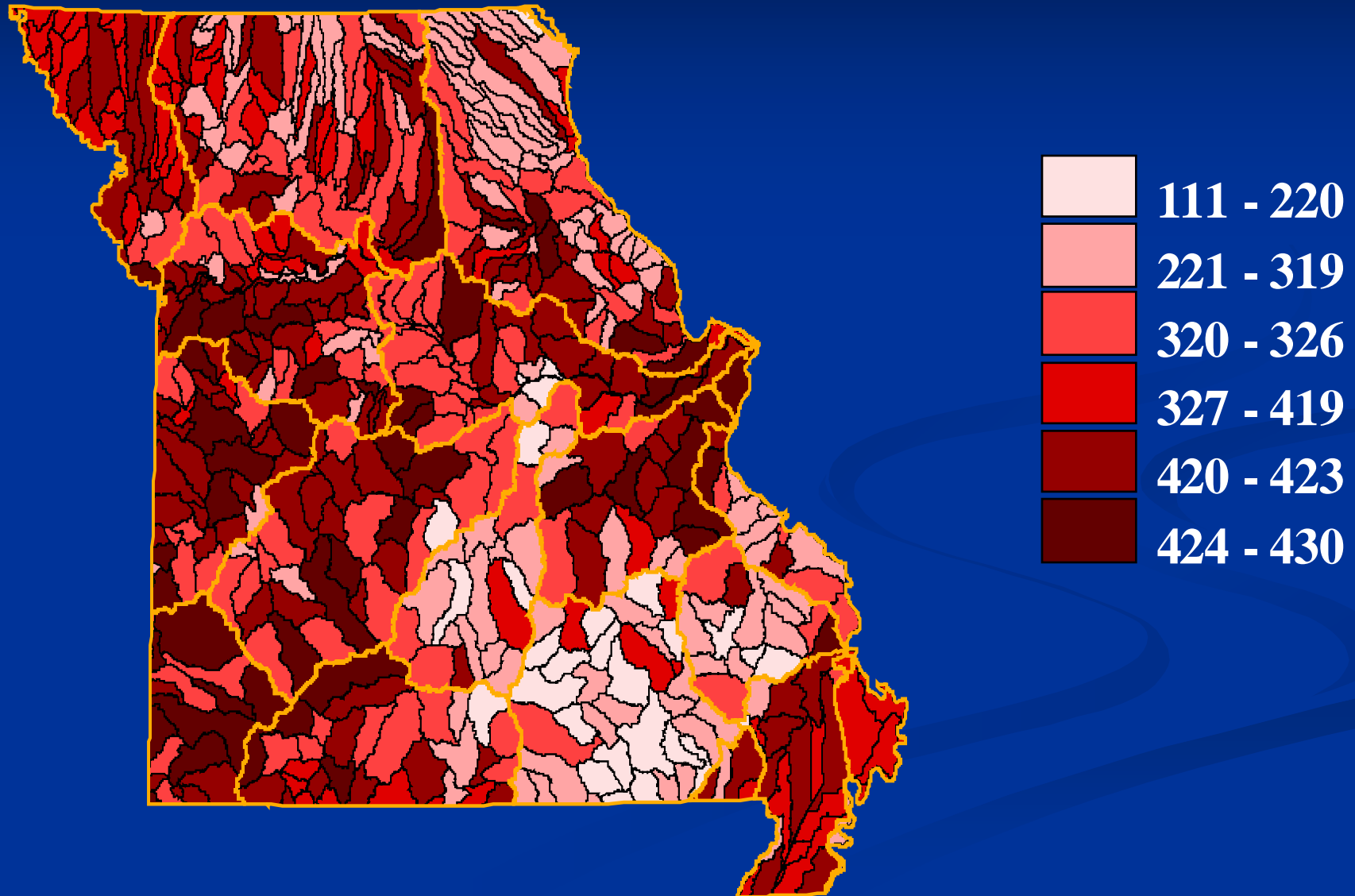
Goal:

Develop reach scale GIS-based Synoptic Human Threat Indices (HTI) for assessing ecological integrity of freshwater ecosystems

EPA Region 7
Iowa, Kansas, Missouri, Nebraska



Missouri Example: Human Threat Index (HTI)



Limitations with Missouri HTI

- Large assessment unit
 - 237 Sq. Km average
- Does not account for contributing area outside of individual sub-watershed polygon
 - Local polygon only
- Limited number of “threat” datasets as input
 - Eleven

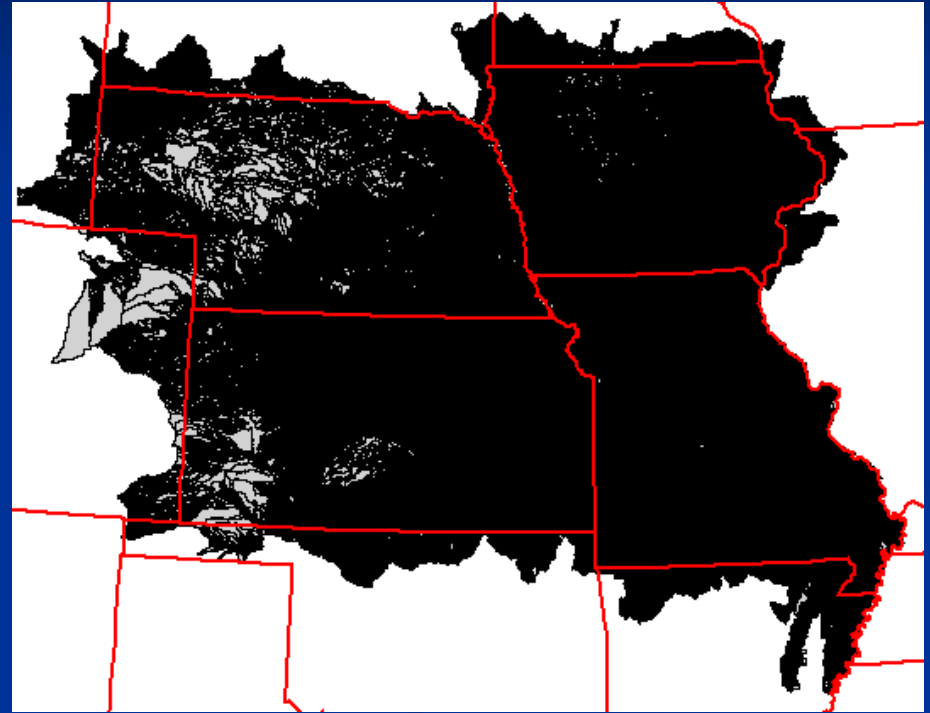
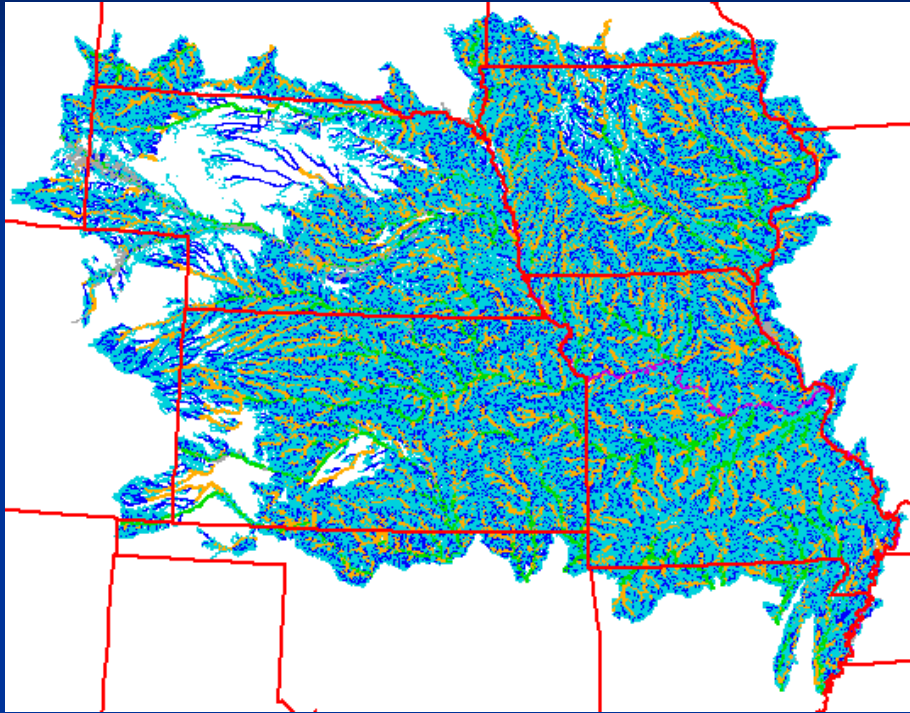
EPA Region 7 Primary Objectives:

- Create a “threat assessment tool” useful for on the ground management
 - Fine resolution
- Utilize as many threat datasets as possible
- Consider the drainage area above each stream segment
- Consider riparian condition
- Account for distance
- Useful for five components of ecological integrity

Methods

- Establish a Regional Oversight Committee
 - “Experts” from each state
- Conduct Literature Review
- Create assessment units
- Gather “threat” datasets
- Quantify “threats”
 - Local
 - Watershed
 - Riparian
- Rank and create Threat Index

Assessment Units



385,000 primary channel stream segments → corresponding catchment polygons

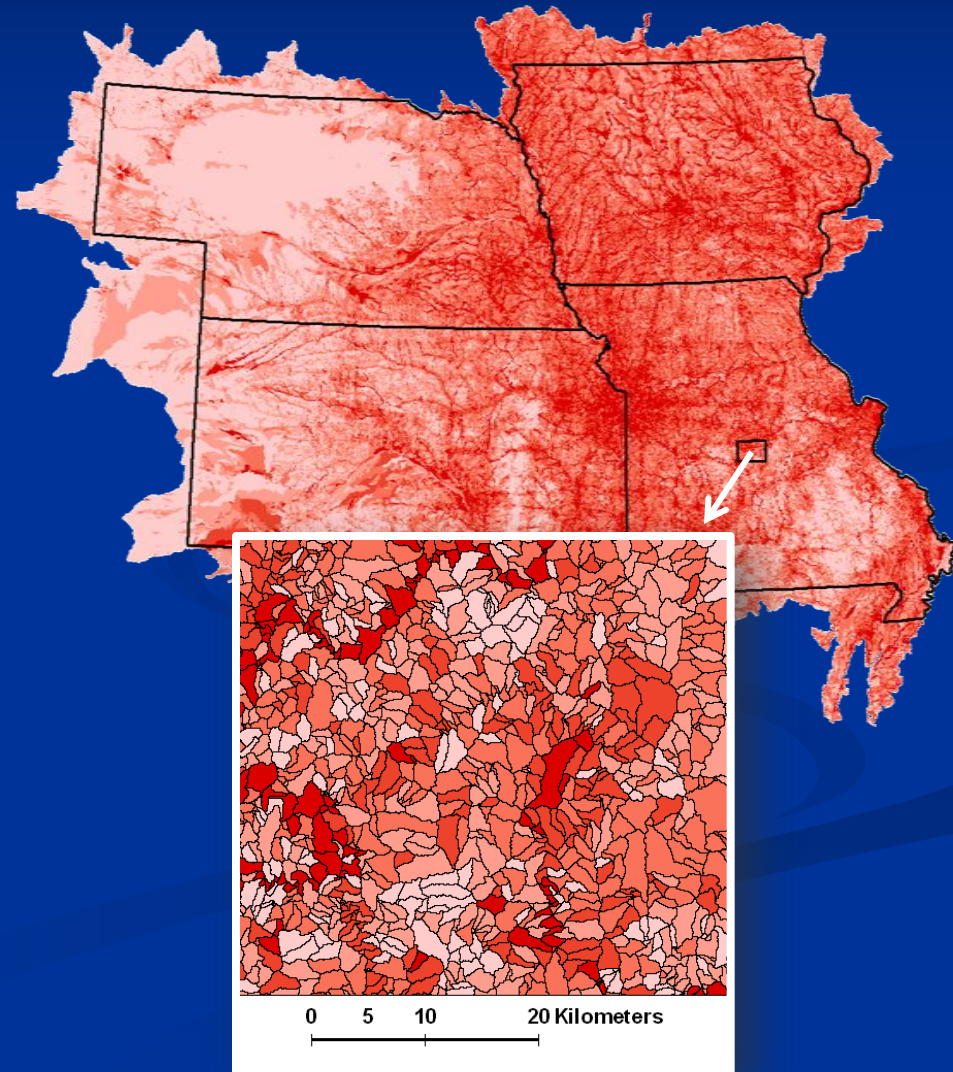
And Stream Buffers (riparian condition)

Small Assessment Units

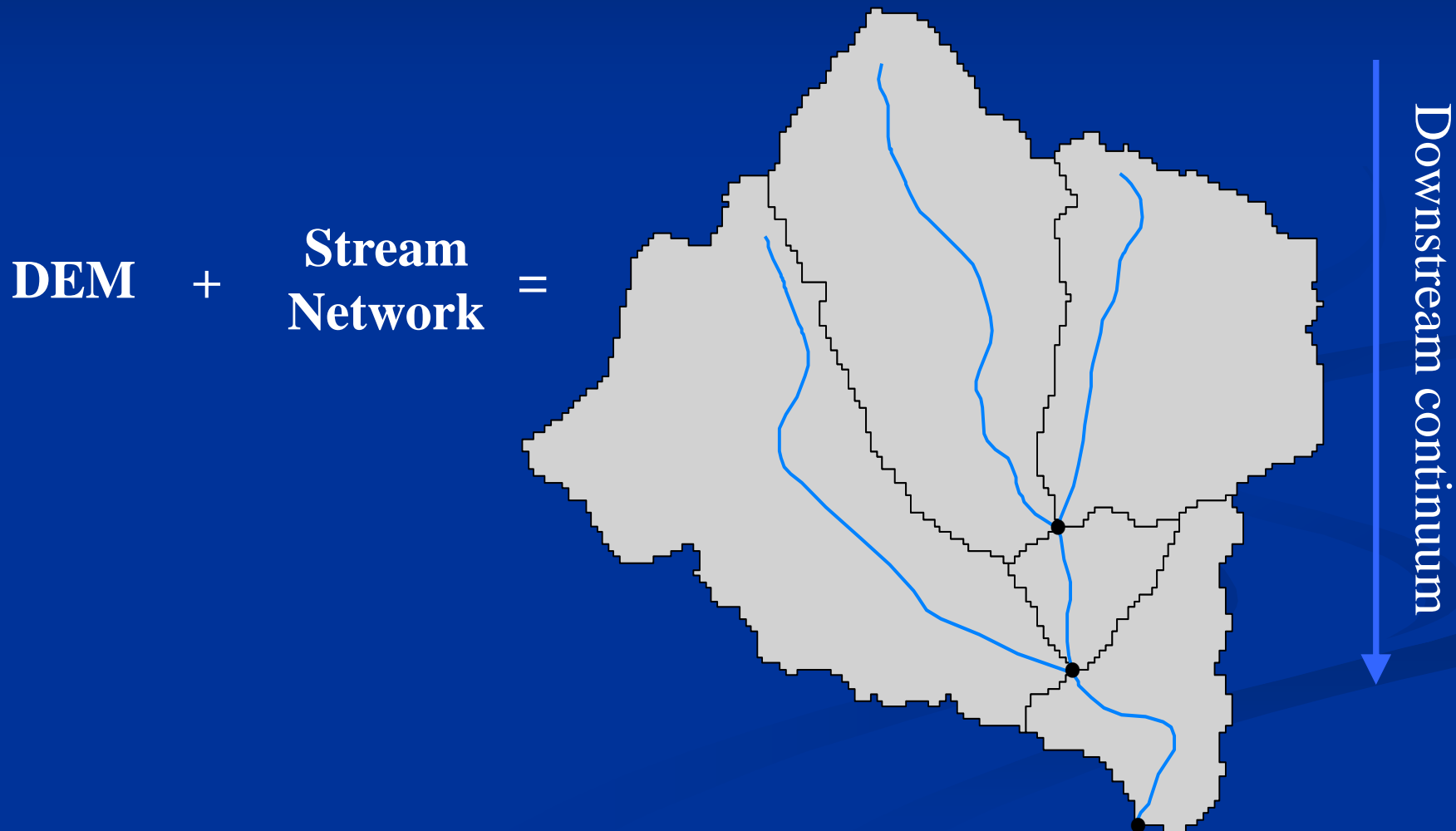
Assessment Units



— Streams
□ Assessment Polygon



Watersheds / Catchments / Segment sheds / Reach Specific Drainage Areas



Stream Segments Linked to Catchments

- 1 to 1 relationship
 - Stream segments & polygons
- Watershed properties can be accumulated downstream
 - Total drainage area, point sources, length of road, land cover, etc.
 - Can be converted to a proportion of the drainage area or stream miles



Gathering Threat Data

- Brainstorming with Regional Oversight Committee
- Data search
- More challenging than expected
 - Must be consistent over 4 state area
- Data issues
 - Completeness
 - Multiple sources of the “same” data
 - Location

Threat Datasets

Agriculture:

Cropland
Pasture/rangeland
Row crop chemicals
Pasture chemicals
CAFO

Stream alteration:

Dams
Major reservoirs
Headwater impoundments
Channelization
Distance to reservoir
Fragmentation

Transportation:

Airports
Length of road
Road – stream crossings
Length of Railroads
Rail – stream crossings

Human infrastructure:

Population change
Power lines
Pipelines
Wells
Military sites
Impervious surface

Discharge:

LUST
Superfund sites
TRI
NPDES
Landfills
Waste water treatment

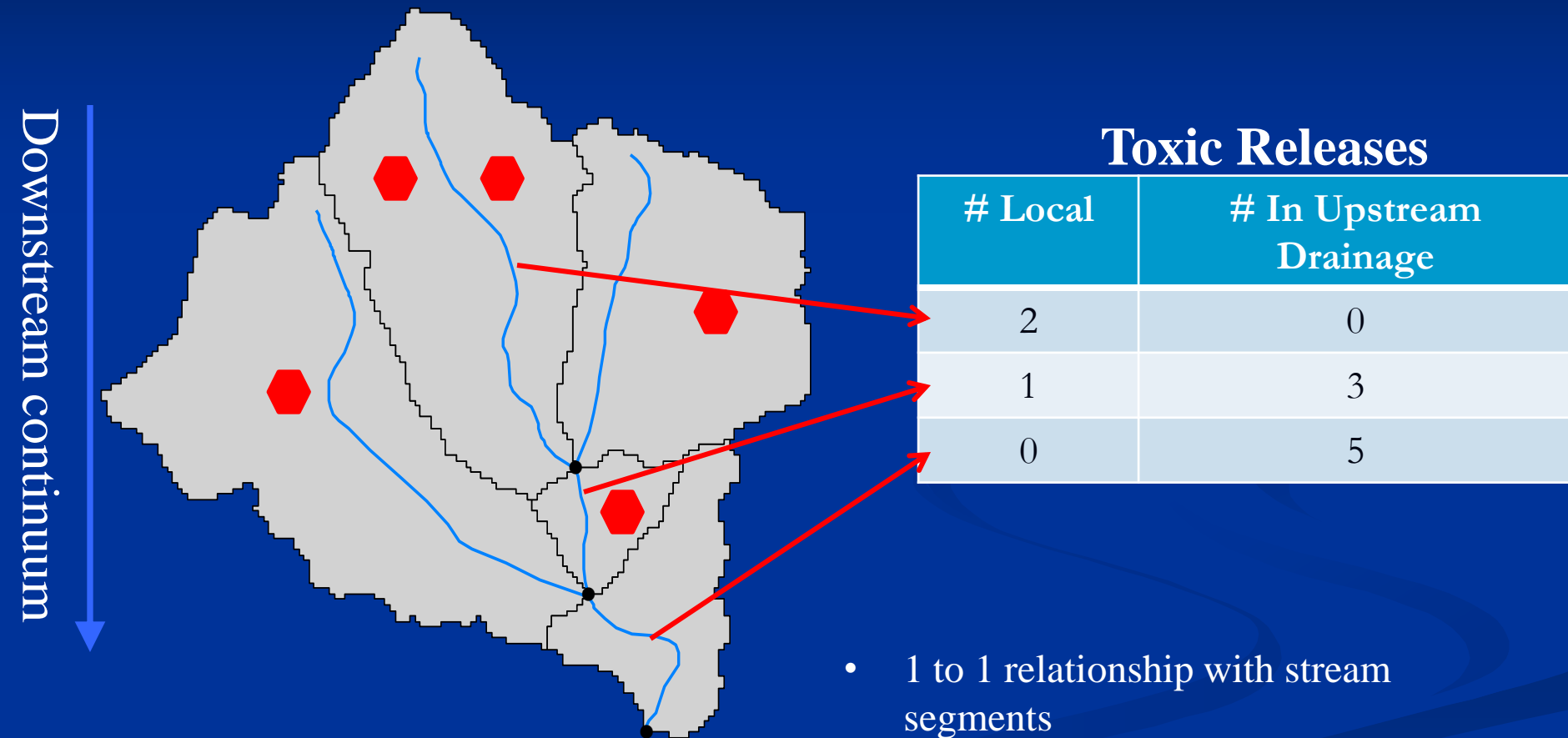
Mining:

Lead mines
Coal mines
Other mines
Oil & gas wells

Quantifying Data

- Overlay threats and catchment polygons
- First, quantify locally
- Next, run programs to quantify everything in the drainage above each stream segment

Quantify Locally Then Everything Upstream

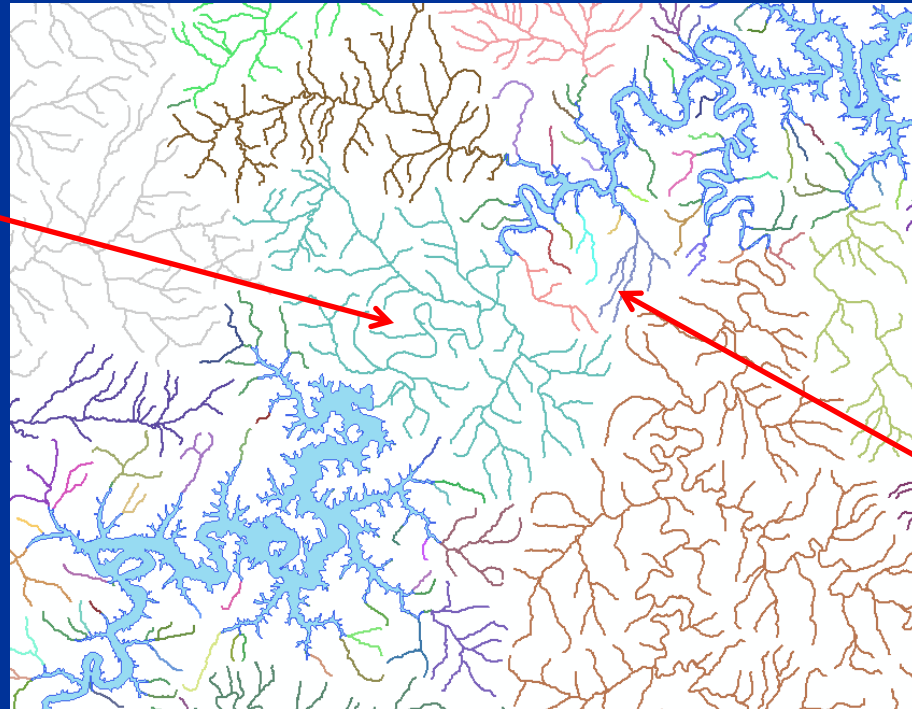


- 1 to 1 relationship with stream segments
- Almost any properties of the watershed can be linked to the stream network for accumulation downstream

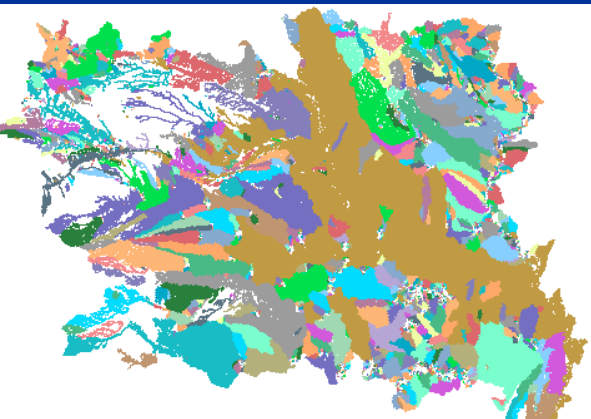
Connectivity / Fragmentation

- How fragmented are the stream networks due to dams/impoundments?
- Total length of interconnected stream
 - i.e. Miles of stream a fish has access to without going through a dam

221 Km of
Stream

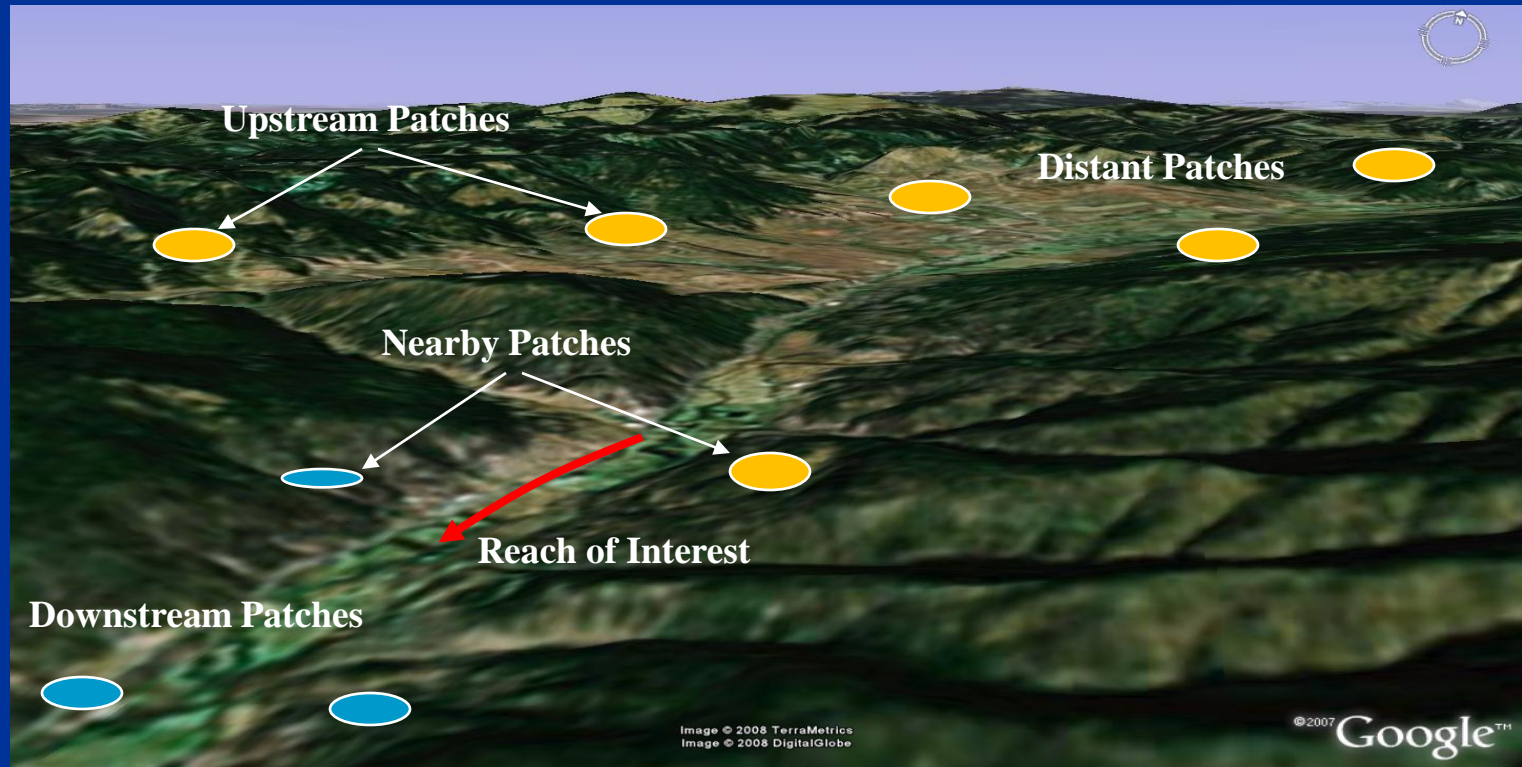


18.7 Km of
Stream



Spatial Distribution of Individual Threats is Important

- Is threat upstream, local, or both?
- Distance to threat



**Ecological Integrity of Riverine Ecosystems is
Dependent Upon Integrity of the Entire Watershed**

Accounting for Distance



Mines Upstream	
Minimum Distance	3 Km
Mean Distance	16.5 Km

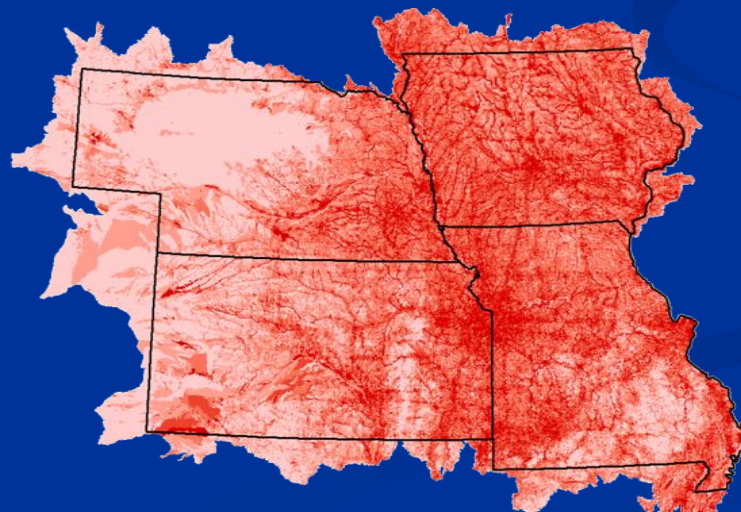
Rank Quantified Data

- Large table with info about each threat dataset
 - Local and upstream information
- Each will be assigned a relative rank

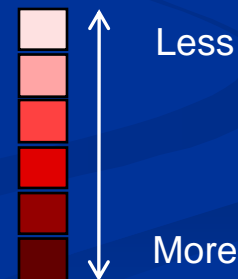
Example Only	Relative Ranks			
Metric	1	2	3	4
% Agriculture	0-25	26-50	51-75	>75
Density of Road-Stream Crossings (#/Sq. Km)	0-0.24	0.25-0.49	0.5-0.9	>=1
Population Change 1990-2000 (#/Sq. Km)	-42-0	0.1-14	15-45	>45
Density of Coal Mines (#/Sq. Km)	0	1-5	6-20	>20
Density of CAFOs (#/Sq. Km)	0	1-5	5-10	>10
Degree of Fragmentation	1	2-3	4-5	6
...				

Ranked Data Used to Create Overall Human Threat Index

<i>Dam_mk</i>	<i>Popchg_mk</i>	<i>Coal_mk</i>	<i>Lead_mk</i>	<i>Cato_mk</i>	<i>Max</i>	<i>Sum</i>	<i>HTI</i>
2	2	3	1	2	4	24	424
4	1	3	1	2	4	23	423
2	3	3	1	2	4	25	425
2	1	2	1	2	4	19	419
1	1	2	1	1	4	18	418
2	2	2	1	3	4	24	424
2	1	2	2	2	4	23	423
2	2	2	1	3	4	22	422
2	2	1	1	2	4	20	420
2	1	3	1	3	4	22	422
4	3	3	1	2	4	27	427
2	1	2	1	1	4	20	420



Threats



Account for Components of Ecological Integrity Separately

(Flow regime, Physical habitat, Water quality, Energy/Nutrient dynamics, Biotic interactions)

- Threat X impacts water quality, but has little impact on flow regime
- Threat Y impacts physical habitat, but has little impact on water quality
- Attempt to account for these separately

Resulting Products

- Human Threat Index (HTI)
- Geospatial data archive
- Raw data metrics
 - Related table of actual data
 - Allows display of region by any metric (i.e. mine density)
- Final report

Potential Use for Information

- Watershed inventory & assessment
- Monitoring – Selecting reference sites
- Landowner incentive programs
- Identifying information needs
- Education and Outreach



Progress Since Last Meeting

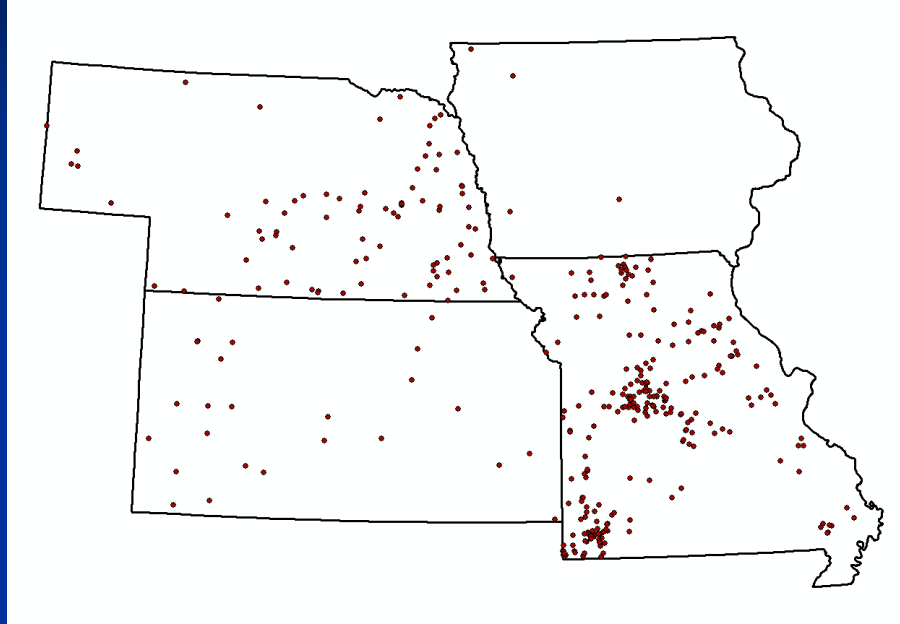
Recent Progress

- Various data issues fixed
- Created channelized streams dataset
- Completed computing distances to threats
- Created modified impervious surface
- Identified headwater impoundments
- Produced riparian buffers
- Dataset error checking complete
- Dataset reports

Data Issues: Concerns Discussed at Last Meeting

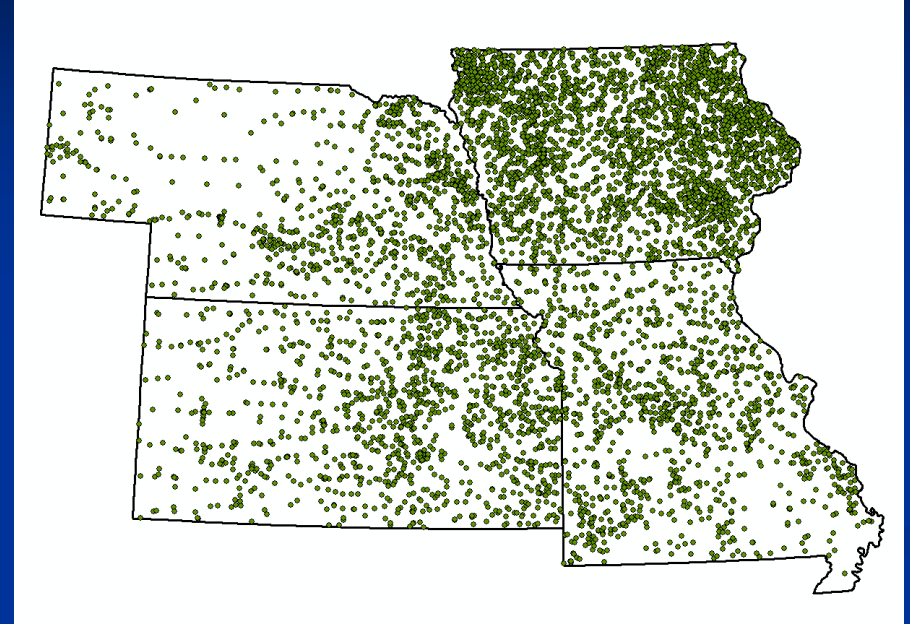
1. CAFOs
2. NPDES
3. In-stream Mining
4. Channelization

Data Issues CAFOs



NPDES CAFO's

1. Data is not consistent across region
2. Some CAFO's are missing
3. Some of the facilities are generalized for the region (i.e. 1 point for many facilities)



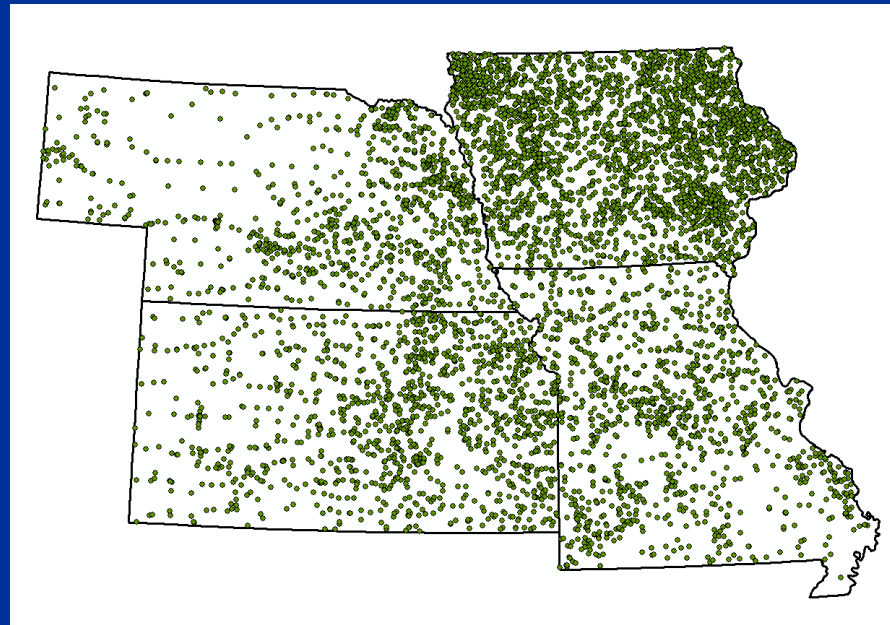
EPA CAFO's

1. Data appears “consistent” across region
2. Misses some facilities
3. Often poor locational accuracy

Data Issues: CAFOs

What we did

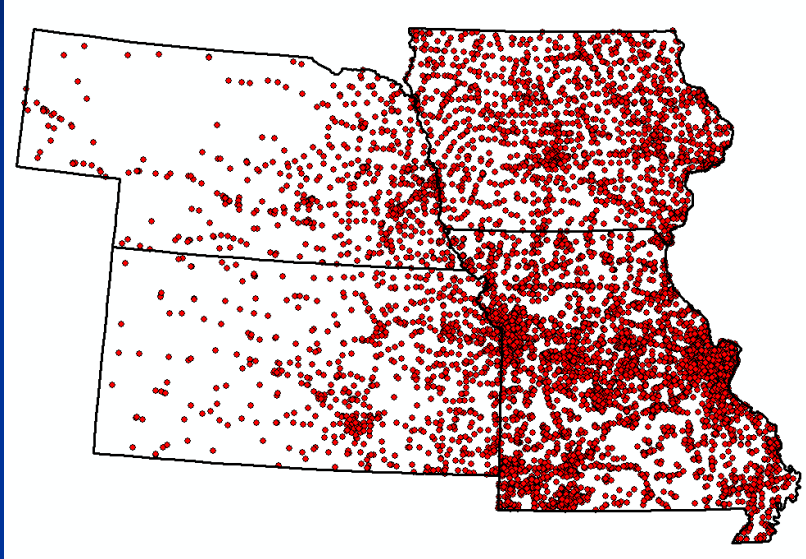
- Decision was made to use the EPA CAFO layer
 - Number of facilities in watershed
 - Total sales in watershed



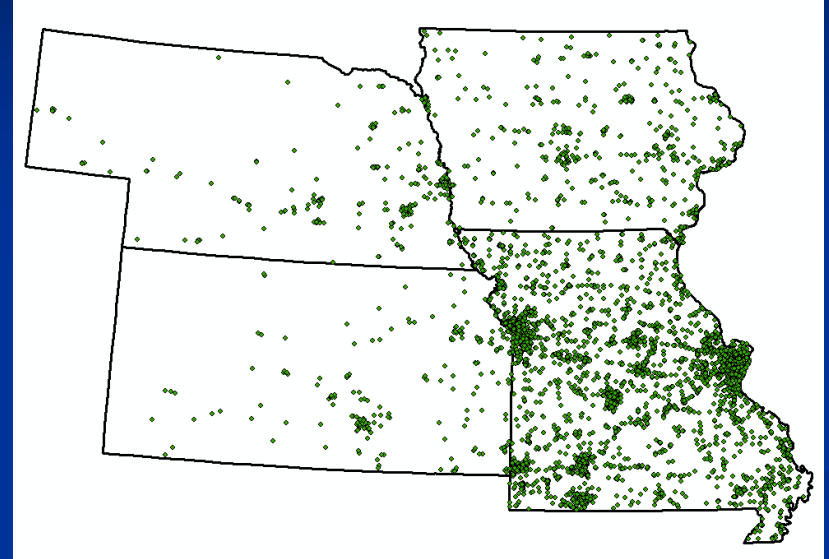
EPA CAFOs

Data Issues: NPDES

NPDES all data



Overlap Removed

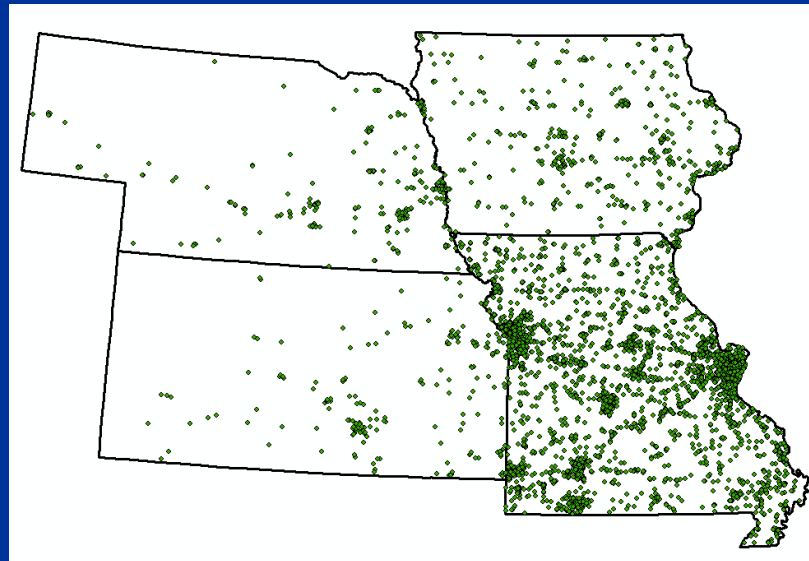


1. NPDES overlaps with other datasets we are using
2. Approximately half the data points remain after removing overlap
3. A large portion of the remaining points are due to construction site permits that are probably no longer there.
4. Other types of remaining points are service stations, farm supply stores and water supplies.

Data Issues: NPDES

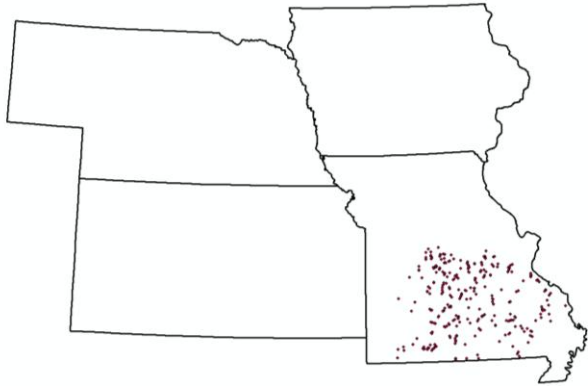
What we did

- Group decided we should use remaining NPDES points
 - Excluded temporary construction sites



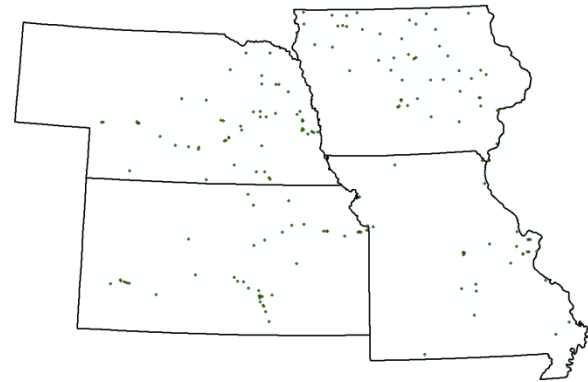
NPDES without Overlap

Data Issues: In-Stream Mines



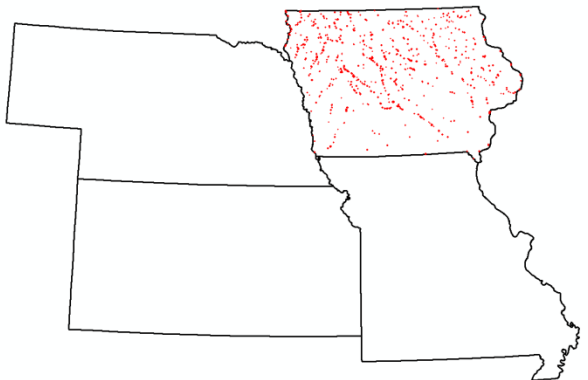
MO DNR - In stream mines

- Sand and gravel



Bureau of Mines Active Mines – Sand and gravel

- This data was extracted from the active mines data, it contains all sand and gravel mines.
- We understand that all sand and gravel mines should be in streams.

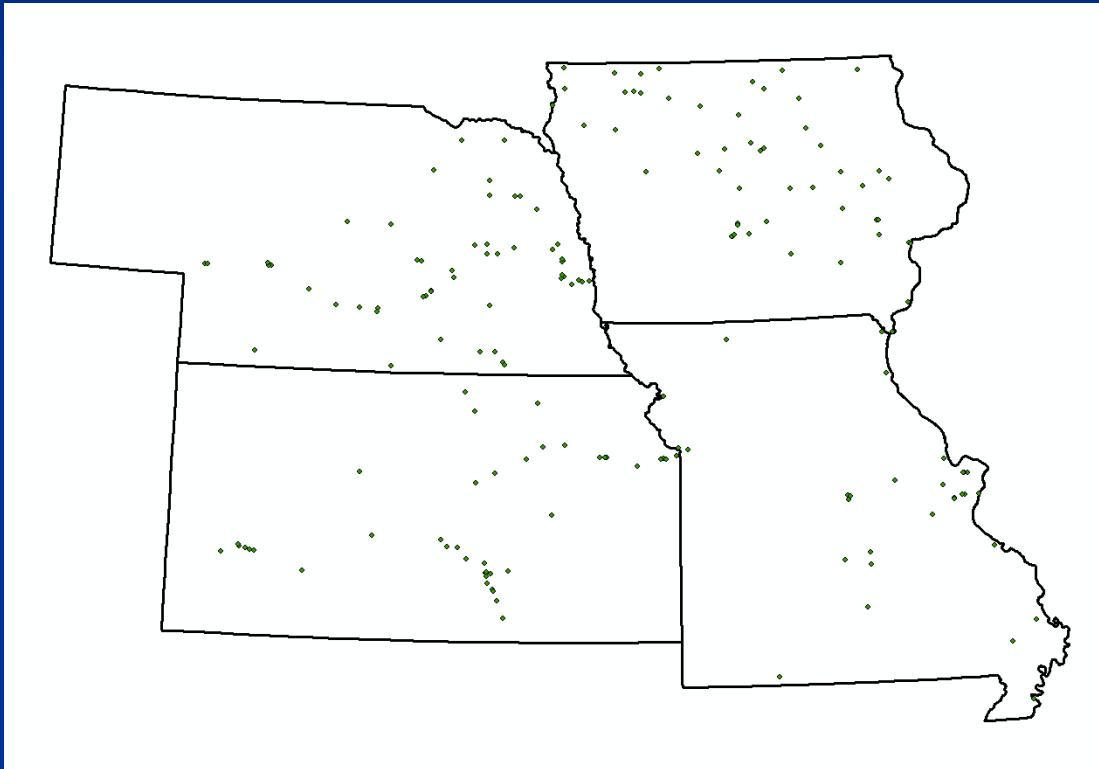


Iowa Mines 2000 – Sand and gravel

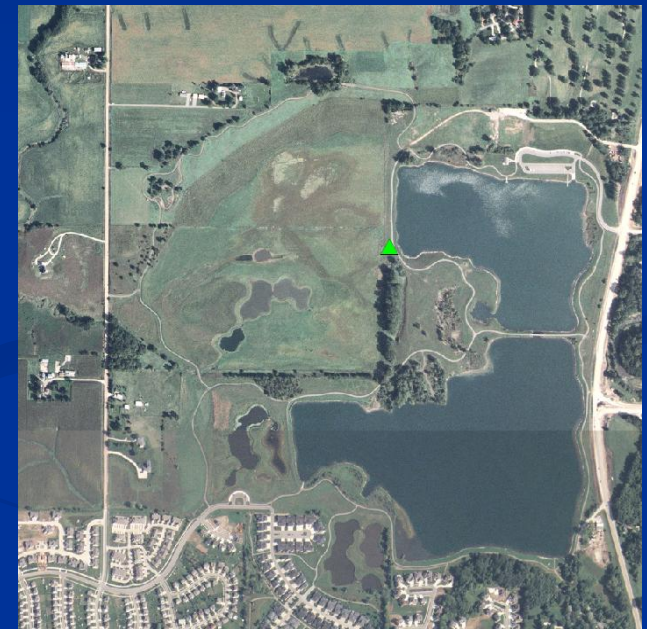
- This data was extracted from the Iowa Mines 2000 dataset, it contains only sand and gravel mines.

Data Issues: In-Stream Mines

Bureau of Mines
Active Mines



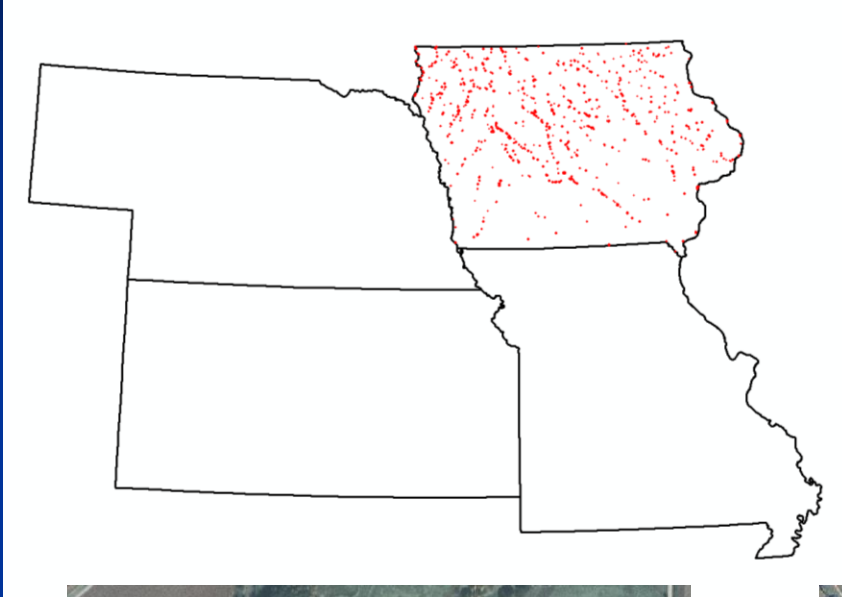
“In Stream” Mine?



The example to the right shows an in stream mining operation at a lake, the closest stream is about almost a mile to the east.

Data Issues: In-Stream Mines

Iowa Mines 2000



- Images show locations of sand/gravel mining operations
- However no visible evidence of any operation within the boundary of the mine.



Data Issues: In-Stream Mines

What we did

- Did not utilize in-stream mines
 - Too many missing
 - Property vs. active mines
- Any in-stream mines in Active Mines dataset were run with “other” mines

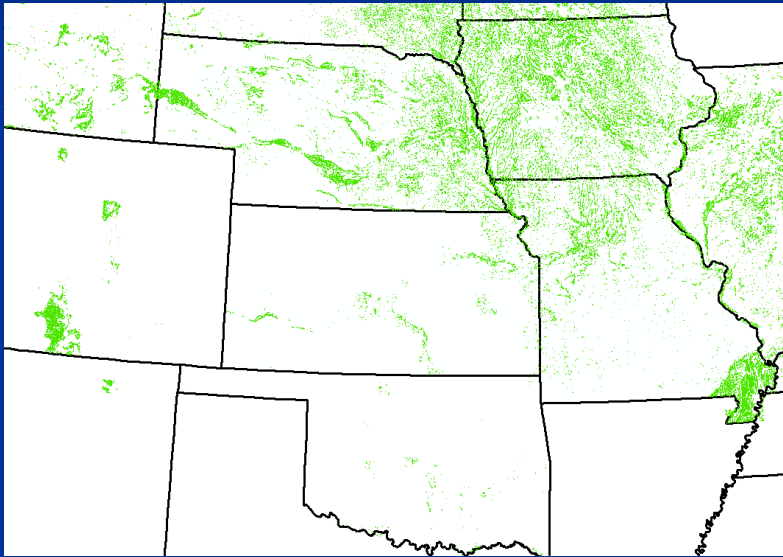
Data Issues: Channelization

- Sinuosity/straightness type programs
 - Introduce error
- Angle calculation
 - Introduce error
- NWI
 - Incomplete coverage for Region 7 (Kansas)
 - Misses some channelization/ditches
 - Different resolution lines
 - Attribution

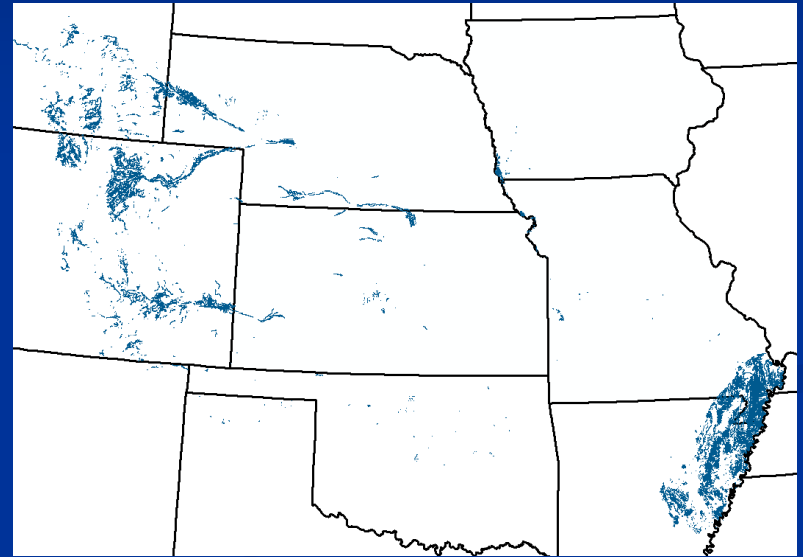
Data Issues: Channelization

What we did

NWI



24k NHD



- Combined NWI and 24k NHD and removed overlap

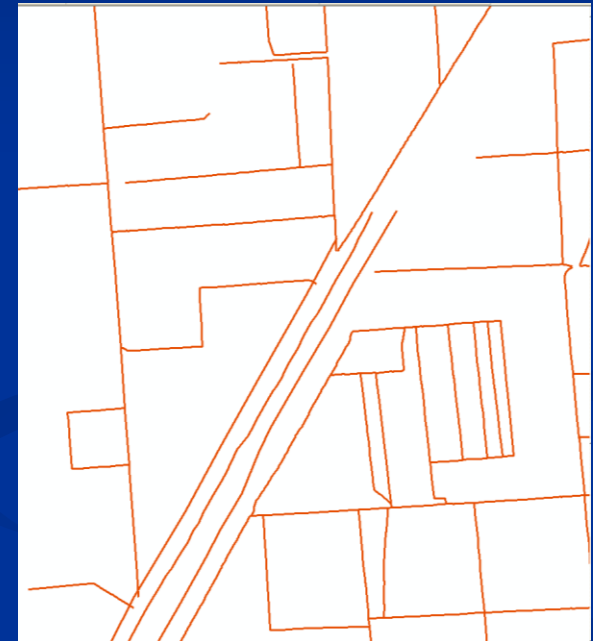
Data Issues: Channelization

What we did

NWI and NHD streams (with overlap)



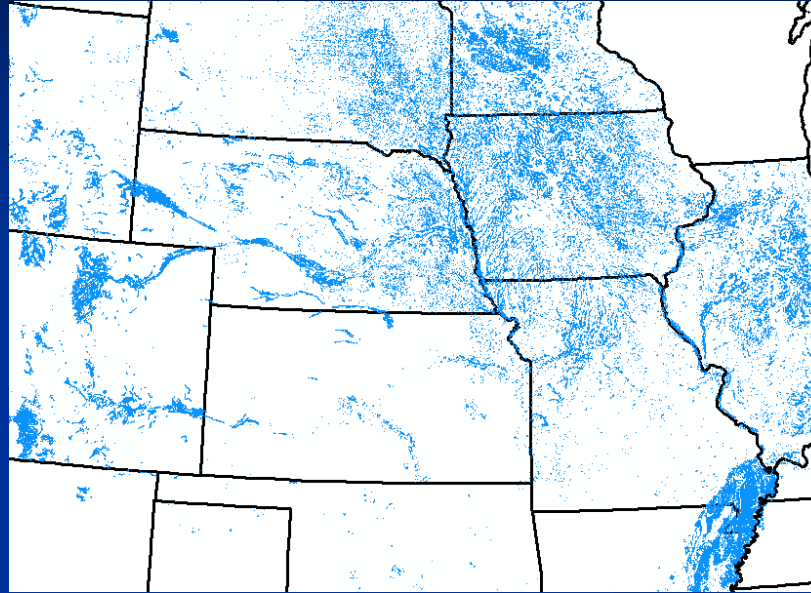
Merged stream file (overlap removed)



- Buffered the NHD streams by 100m
- Maintained any NWI stream that did not have its centroid in the buffers

Data Issues: Channelization

What we did



NWI + 24k NHD = High Resolution ditch layer

- Used the ditches from NWI and 24k NHD to tag 100k NHD streams
- Computed total length of ditch using the “high resolution” ditches

Accounting for Distance

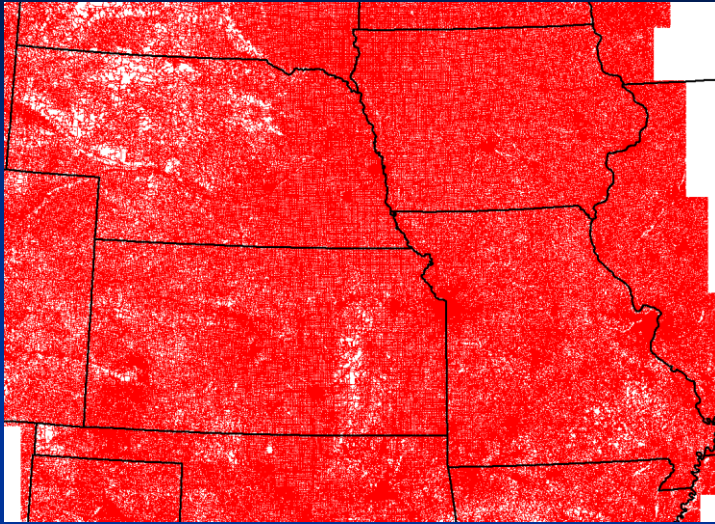
Completed Distance Computations

Average and Minimum Distances

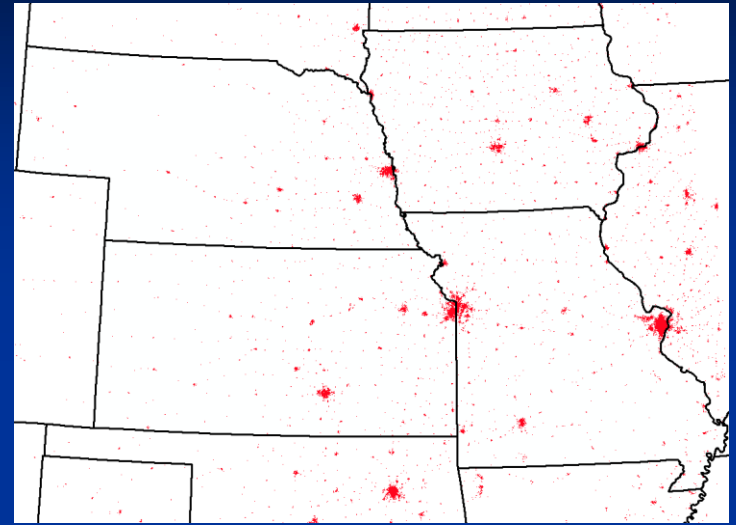
- Airports
- Dams
- Military Sites
- Coal mines
- Lead mines
- Leaking underground Storage Tanks
- Mines
- Oil and Gas Wells
- Superfund Sites
- Toxic Releases
- Waste Water Treatment Facilities
- CAFO's
- Landfills
- NPDES Sites
- RCRIS Sites

New/Improved Source Data

Impervious Surface



NLCD Impervious



Modified for Use

- NLCD pixels tagged as being 1 to 100% impervious
- We wanted to remove roads

Impervious Surface



Wanted to exclude “roads”
from impervious layer

Roads are already accounted
for

A 30 meter pixel is too large to
accurately represent most roads

Impervious Surface

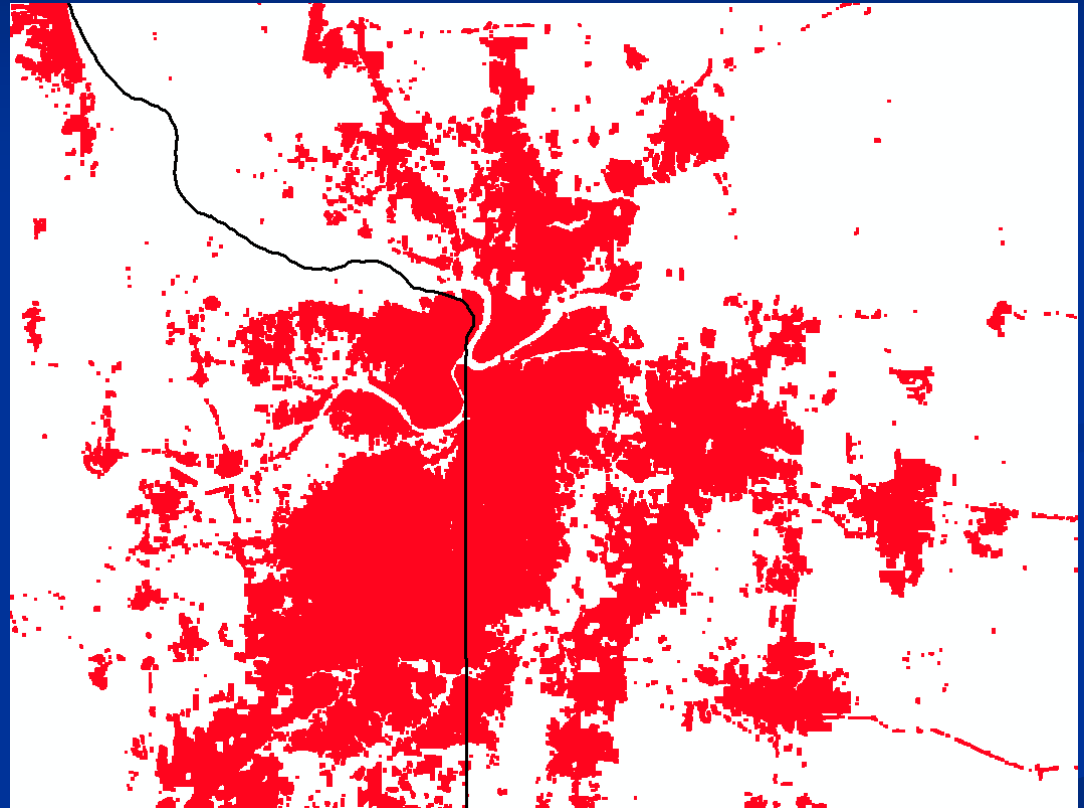
Original 2001 NLCD Urban Area

- Step 1
 - Shrink the raster by 3 pixels to remove most roads.

Remaining impervious surface data

- Step 2
 - Expand the raster by 3 pixels to restore lost areas of data around larger impervious areas.

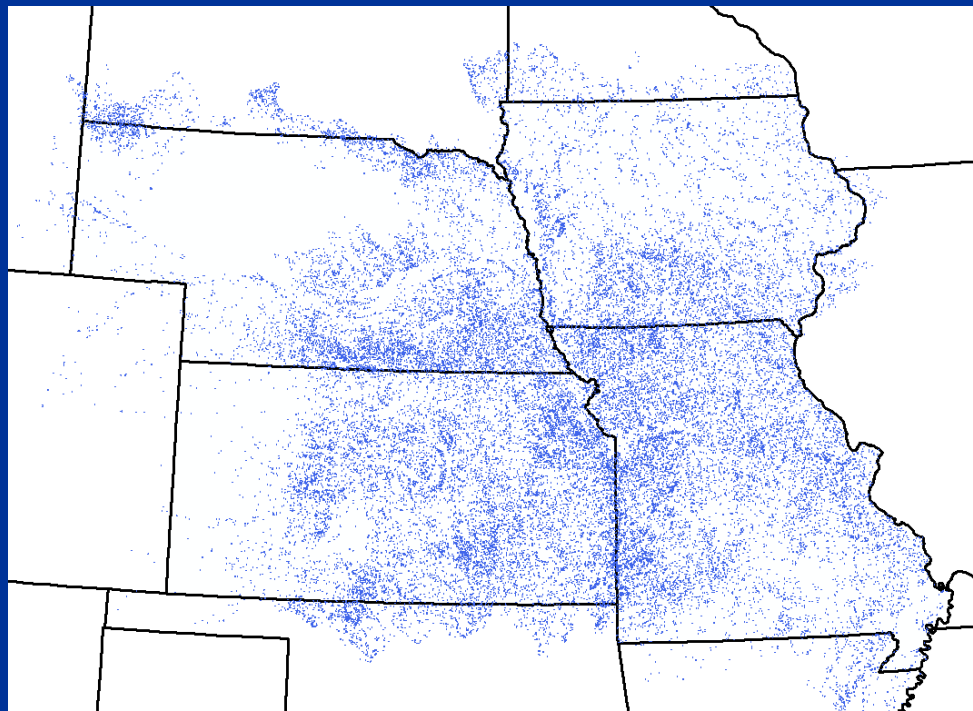
Resulting final file



Kansas City

Headwater Impoundments

- Did not exist for EPA Region 7
- Created a new layer using various sources

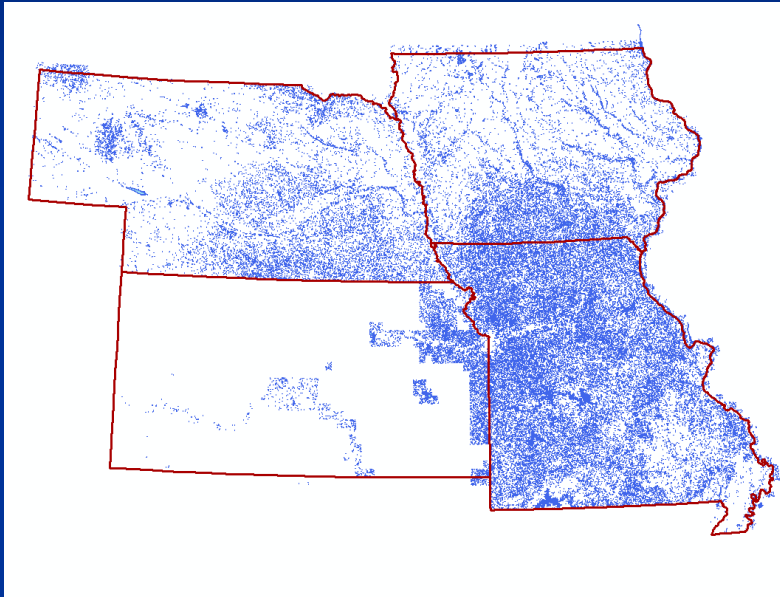


MoRAP Headwater Impoundments

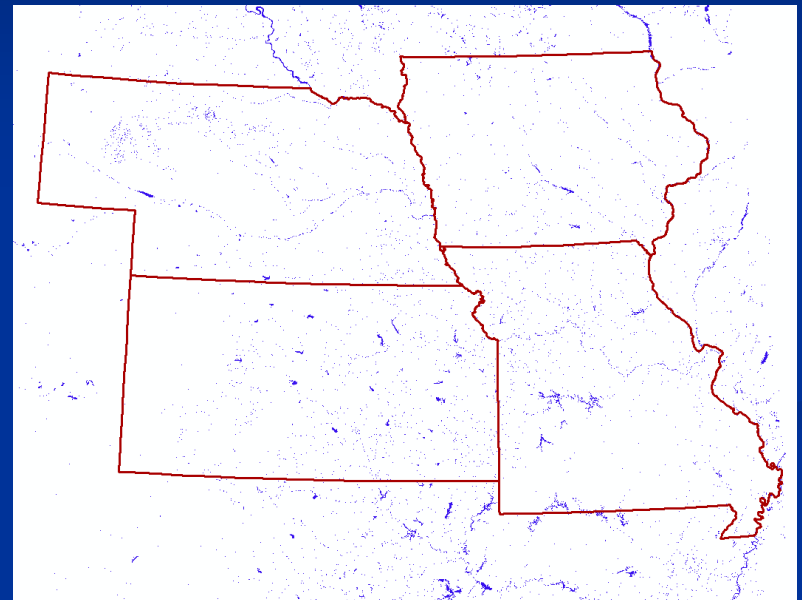
Headwater Impoundments

Waterbody Source Data

NWI

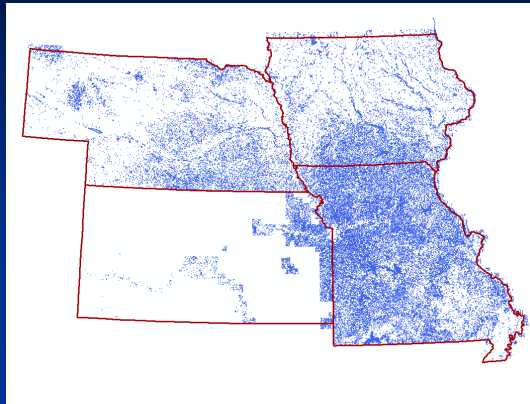


NLCD

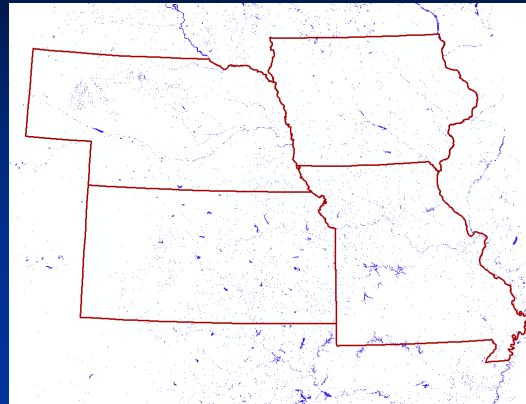


- We subset these data sources to pull out “headwater impoundments”

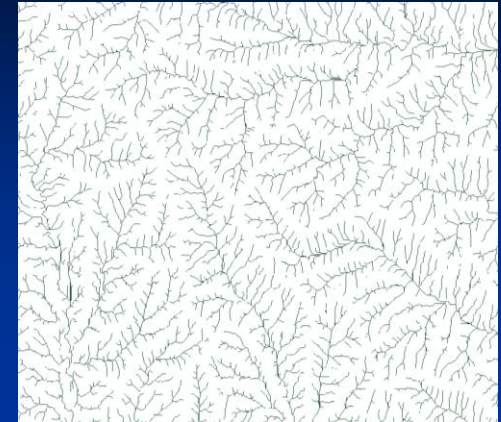
Headwater Impoundments



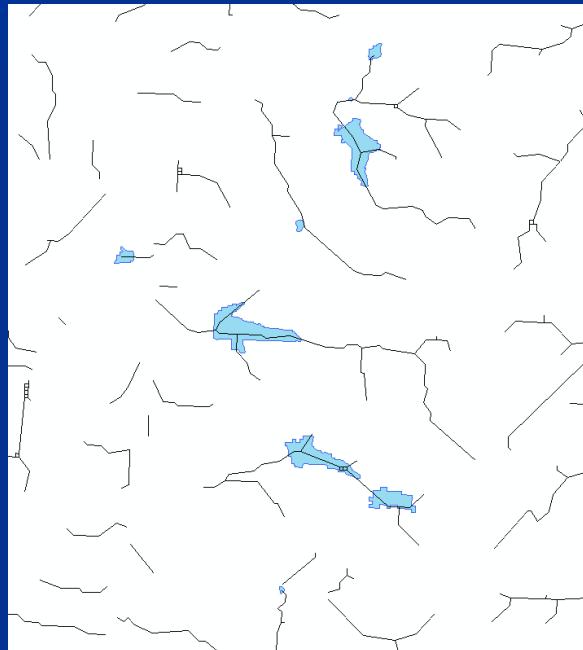
NWI



NLCD

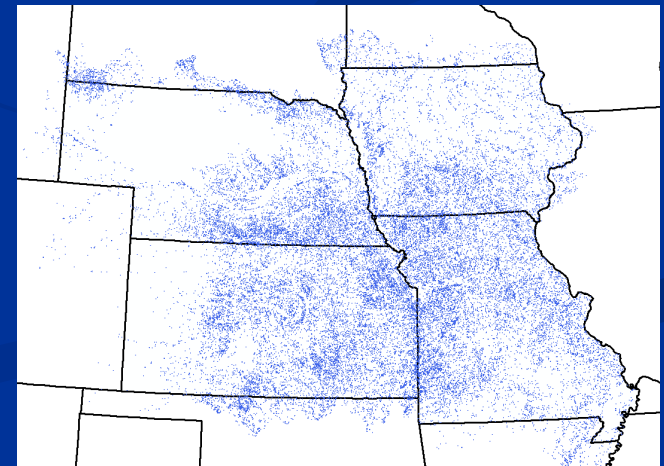


300 Cell Stream Network



Headwater Impoundments

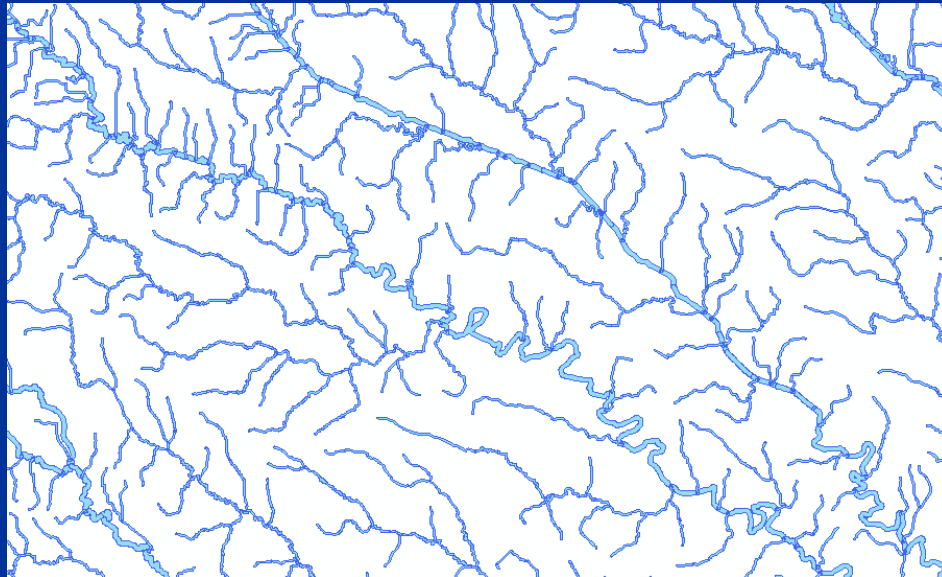
- Wanted to exclude “natural lakes”
 - Performed intersection with Iowa’s natural lakes layer and Kansas playa lakes layer
 - Removed all non-dam lakes from the Sand Hills of Nebraska
 - Used professional judgment to manually remove other “natural” lakes



End Result

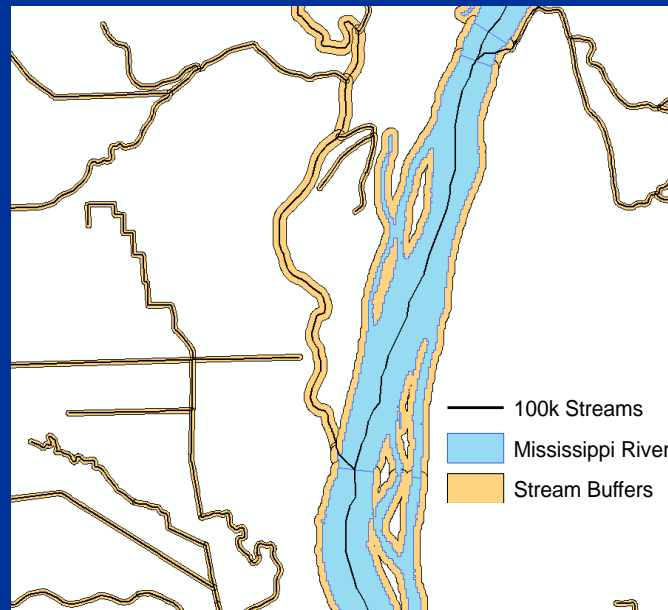
Riparian Buffers

- Wanted to quantify landcover within a stream buffer
- Headwater and Creeks were buffered by 45m and Small and Large rivers were buffered by 105m

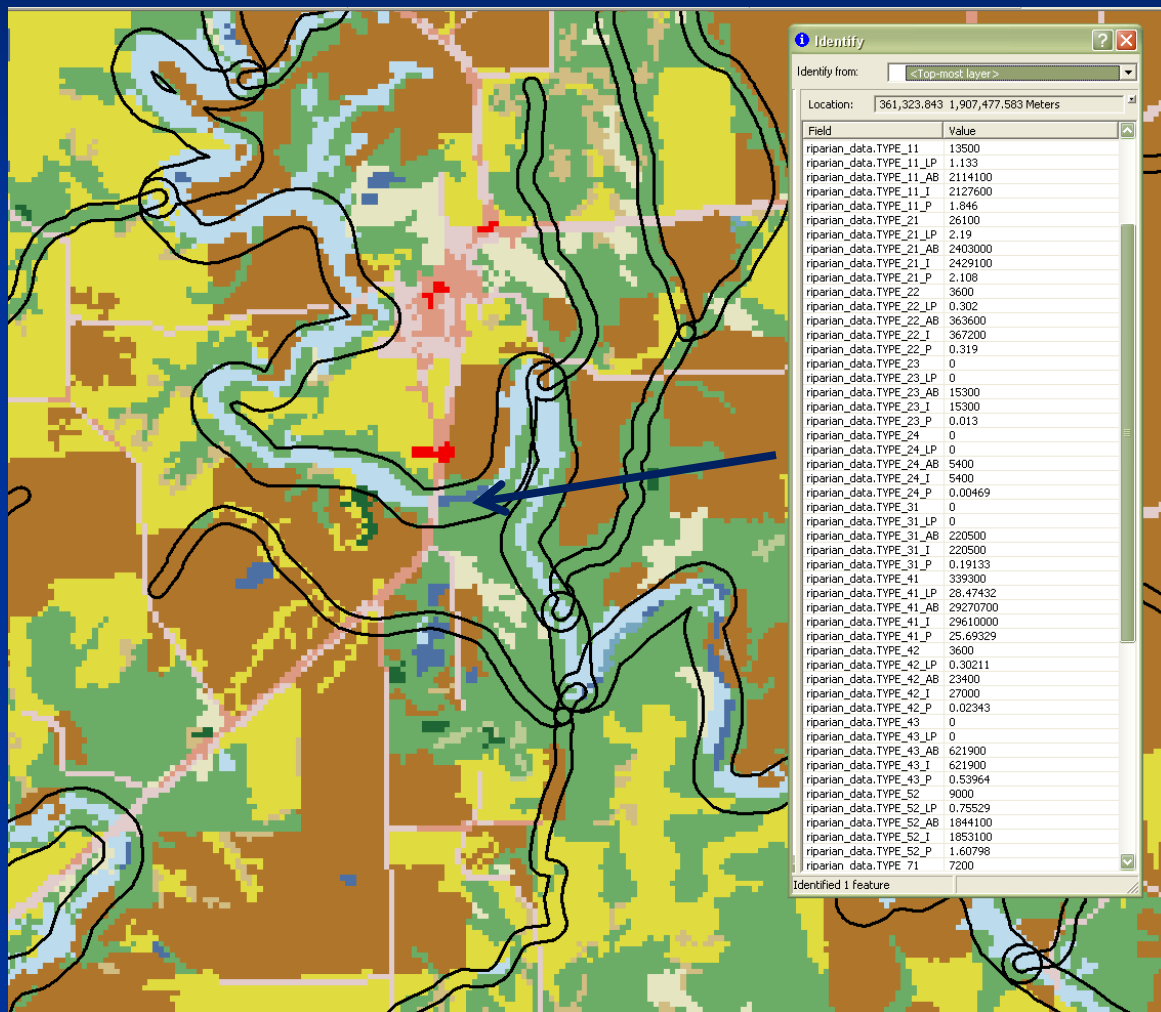


Riparian Buffers

- Different process for Missouri and Mississippi Rivers
 - Extracted from NLCD
 - Clipped manually to stream segments
 - Resulting polygons buffered by 105 meters



Riparian Buffers

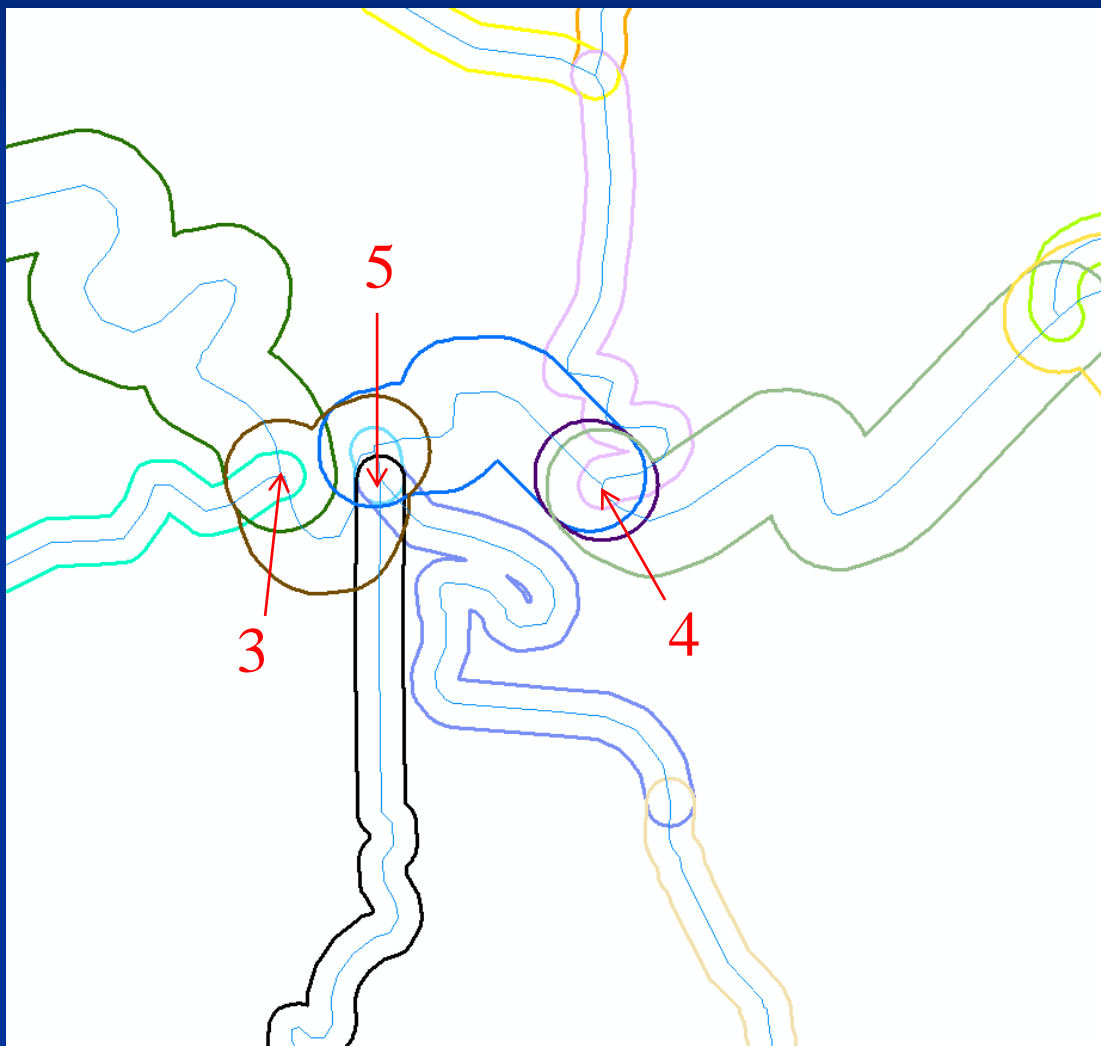


Riparian Buffer Land Cover (2001 NLCD)

- Local tabulated amounts of each class.
- Local percentage of stream buffer in each class.
- Total amount above each reach in each class.
- Total amount of watershed in each class.
- Total percentage of watershed in each class.

Riparian Buffers

Issues for Accumulation



Areas at stream confluences will get tabulated multiple times.

Several methods were attempted to fix this issue, and each method introduced its own type of error.

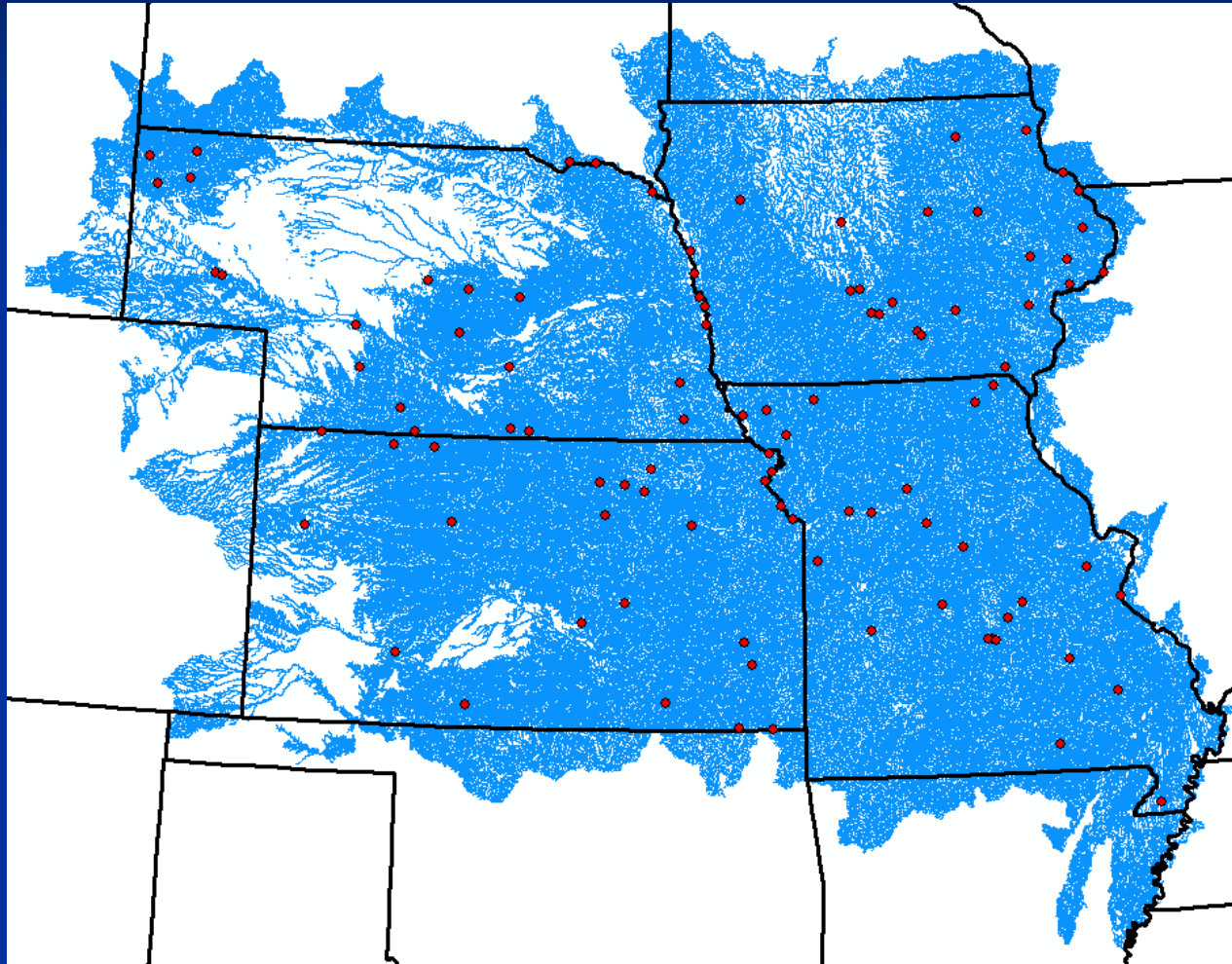
Riparian Buffers

Issues for Accumulation

- Were not going to use the traces for buffers because of overlap issue
- However, . . . Decided to do so
 - Still yields useful information for what is in upstream riparian area

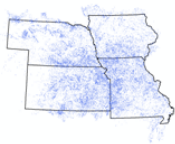
Error Checking

100 Random Locations - Complete



Dataset Reports

Headwater Impoundment



Files

- The final file that contains headwater impoundments of our specifications is called headwater impoundments all.
- EDNA flow direction for our study area.
- We have created a flow accumulation grid.
- We created a Stream Net grid that shows the streams in our region.
- We have created a Strahler ordering stream file for the region.
- NLCD 2001 open water
- NWI Water bodies

Positioning

- Positioning is based on the EDNA raster data, NWI and NLCD

Designation

- Only used open water classification from the NLCD 2001.

- Only used freshwater ponds and lakes from the NWI data.

Modifications

- In order to get the headwater impoundments we first had to obtain a flow direction grid from the EDNA data.
- After we had the flow dir grid we clipped it to our study area so that flow accumulation would not get messed up from the outside areas.
- We then ran the spatial analyst hydrology tool to create a flow accumulation grid based on the flow direction.
- We then used the Stream Link command to create a stream network based on the flow direction and flow accumulation grid.
- After we had a stream file we ran the stream ordering command to create a Strahler stream ordering system, we also tried to run a Shreve ordering system however it ran for three weeks and we decided to kill the process.
- The next process ran was to reclassify the stream order grid so that we only had Strahler 1 and 2 order streams or headwaters.

- Next the streams needed to be converted into polygons so that we could use them to intersect with water bodies, several processes were used in order to do this, we used spatial analyst as well as conversion tools in Arc Toolbox, we tried to use the gridfish command in ArcToolbox and that also failed, the way in which the process finally ran is by downloading a script from the ESRI website that ran in Arc View, before this was able to run I had to break apart the stream file into 16 regions in order to have a manageable size, these files were then exported to a file geodatabase.
- The next step to determine headwater impoundments was to extract the water bodies in order to intersect them with the stream lines.
- Open water classifications were reclassified from the 2001 NLCD to have a single class.
- The next process ran was the region group command in order to combine the water bodies into specific water bodies instead of single pixels.
- Next the size classes had to be extracted from the resulting file, the file was too large to extract all at once so the water file also had to be cut into 16 regions in order to extract the data.
- The way that the water was extracted by size class was by using the extract by attributes command and selecting only region groups that contained less than 122 pixels which is equivalent to less than 50 acres.
- The next step needs to be cleaning both the water body file and the stream file because some streams are classified in the waterbody file and the stream file has some connectivity problems.
- Next I converted the raster data to polygons in order to start working with the NWI data with them.
- I then removed any river polygons in the NLCD by selecting the river polygons in the NWI and then intersecting them with the NLCD, any intersections were deleted.
- The next step was to extract the NWI for the 16 regions, to do this the NWI polygons were clipped to the region and if any overlap between states occurred the NWI pieces were merged together.
- After I had the NWI for each region I could then extract the data that was not necessary for our purposes, this included any polygons that was not a lake or a pond.
- Next the NLCD and the NWI files were merged together to have a single more complete file of water bodies, to get the polygons from both original files to merge into a single polygon I had to use the merge and explode multipoint feature tools in editor.
- Next the areas of the polygons had to be calculated using the **XXTools** command to generate area.
- After area was calculated any waterbody that was over 50 acres was excluded from the file.
- The results are a single water body file that is comprised of the NLCD and NWI water less than 50 acres.

- The next step is to clean the file by using the valley segment polygons and intersect them with the water bodies then manually remove the polygons that are rivers or are not impoundments.
- The process to remove unwanted polygons was very time consuming, the way that polygons were removed is if they intersected the floodplain and if they looked like they were natural lakes like oxbows or if they were smaller if they were an impoundment or if they intersected a stream size 2 or larger.
- The resulting water bodies were then intersected with the stream file that was created earlier, any water body that intersected a stream was exported to a new file where they are merged and combined into a single file for EPA Region 7 that shows the headwater impoundments.
- In an attempt to try to limit the number of natural water bodies in our file we used several other files to extract possible unwanted water bodies, we did this in response to request from project reviewers.
- The first file we used was a shape file of the playa lakes region in western Kansas, to remove water from this area we simply intersected or lakes with the playa lakes, any intersections were removed from our file.
- The second file that we used to limit water sources was the sand hills region of Nebraska, we didn't have a shape file of water bodies that were natural lakes in this area, so we masked out all lakes that were in this region designated by Diana True at MoRAP, and only kept the lakes that were within 100m of dams in the region, the dams came from the EPA BASINS and Nebraska's state GIS library.
- The final extraction we did on the final involved the natural lakes in Iowa, to do this we used the protected natural water bodies from the Iowa NRGIS website, we simply removed any water bodies that intersected the other file.
- Traces were then run on the total number of headwater impoundments per catchment.
- The totals were then added to the master file.

Notes

- We have had several issues with the software and the hardware when running some of the processes within ArcMap.
- There is a file size limit for windows, no file can be over 2 GB within a 32 bit.
- There was supposed to be a way around this by the new file geodatabase which limits are 100 GB and 100 million records, however when creating a file within the geodatabase it makes a temporary shapefile outside the geodatabase and therefore if it is over 2 GB kills the process and can't process it.
- These errors have come about when we try to convert the raster to polygons in order to intersect the water polygons.
- Obviously this dataset is not perfect, I am sure we will miss many as well as include many that we shouldn't, this is just an estimation that was made to best of our abilities and resources.

Source

- NWI data
 - o Wetlands www.fws.gov/wetlands page: team

- o DVD sent to us
 - o Obtained - 4/23/2007
 - o Still in production - incomplete
- NLCD 2001
 - o NLCD Consortium
 - o http://www.mnrl.gov/mnrl/2k_nlcd.asp
 - o Obtained - 5/2007
 - o Created - USGS 9/1/2003
 - o USGS EDNA data
 - o Requested from USGS
 - o Kristine L. Vayssi
- EPA Playa Lakes
 - o Wash Foster EPA R7
 - o CD given to us
 - o Obtained 5/2007
- Iowa Natural Lakes
 - o Iowa NRGIS
 - o http://www.iath.iowa.edu/nrgis/la_subhome.htm
 - o Obtained 12/2007
 - o Created 5/21/2006
- Sand Hills Landform Region
 - o MoRAP - Diana True
 - o Obtained 12/2007
- Region 7 Dams
 - o BASINS Version 3.0
 - o June 2001
- Nebraska Dams from the NE DNR Database
 - o <http://www.gisdata.dnr.ne.gov/Dams/index.aspx>
 - o 5/2006

7

6

For every dataset there is a corresponding report that contains:

1. Reference Map
2. Files Used
3. Position Information
4. State Designations
5. Modifications or Process Steps
6. Notes
7. Source Information

Still Working On

- Human Threat Index (HTI)
- Developing separate index for 5 components of ecological integrity
- Field validation

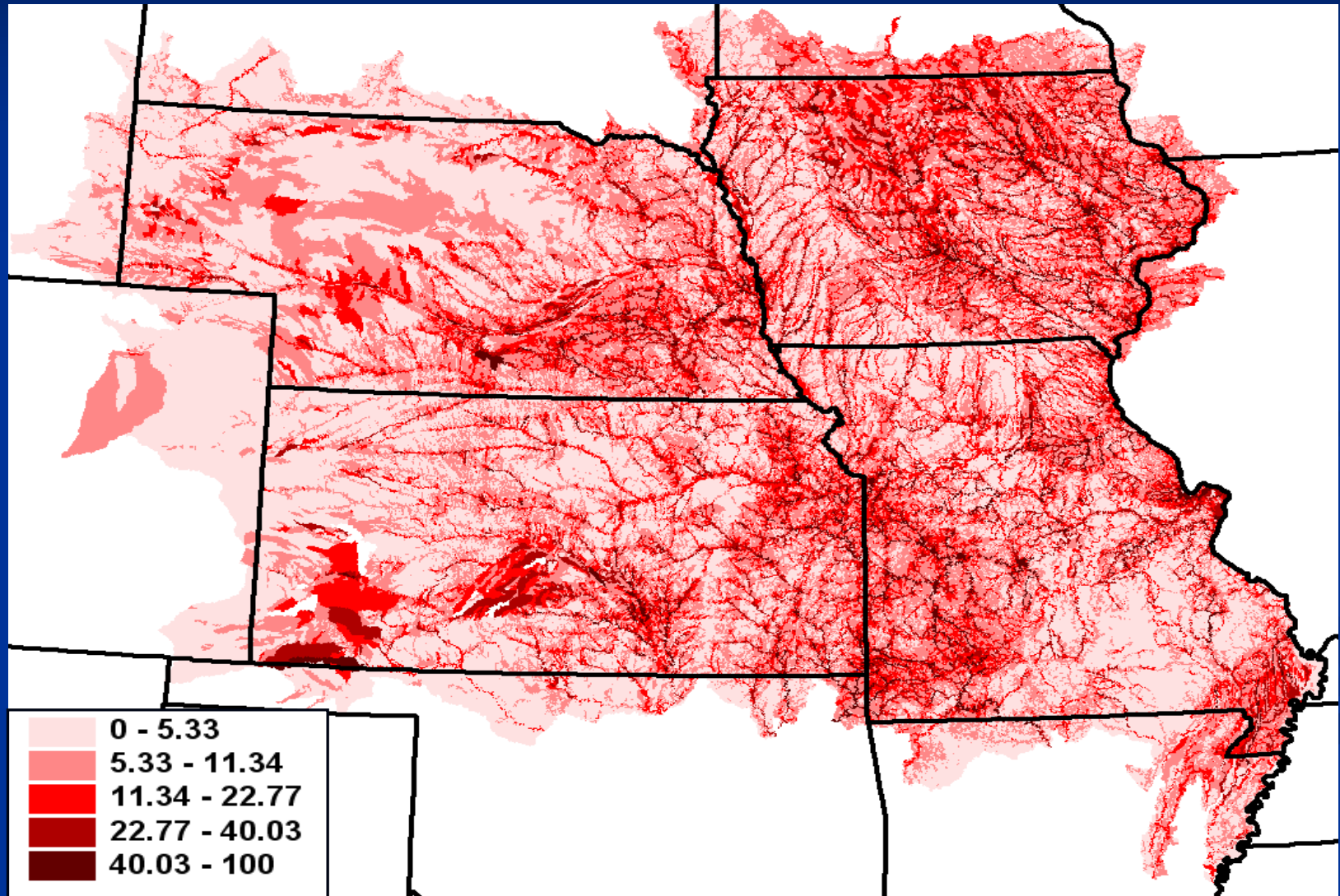
Open Discussion

Data & Methods

Human Threat Index

Methods and Discussion

Preliminary Draft Human Threat Index



HTI Inputs

1. Impervious
2. Cropland
3. Pasture
4. Impervious in stream buffer
5. Crop in stream buffer
6. Pasture in stream buffer
7. Length of road
8. Road/stream crossings
9. Wells
10. Major impoundments
11. Pipelines (crude oil)
12. Pipelines (liquid fuels)
13. Pipelines (natural gas/propane, etc.)
14. Length of rail
15. Rail/stream crossings
16. Power lines
17. Pesticide applications
18. Headwater impoundments
19. Livestock sales
20. Length of ditch
21. Airports
22. Dams
23. Military sites
24. Coal mines
25. Lead mines
26. Other mines
27. LUST
28. Oil & gas wells
29. Superfund sites
30. TRI
31. Waste water treatment
32. CAFOs
33. Landfills
34. NPDES
35. RCRIS
36. Population change
37. Fragment size
38. Stream size classes per fragment
39. Distance above lake

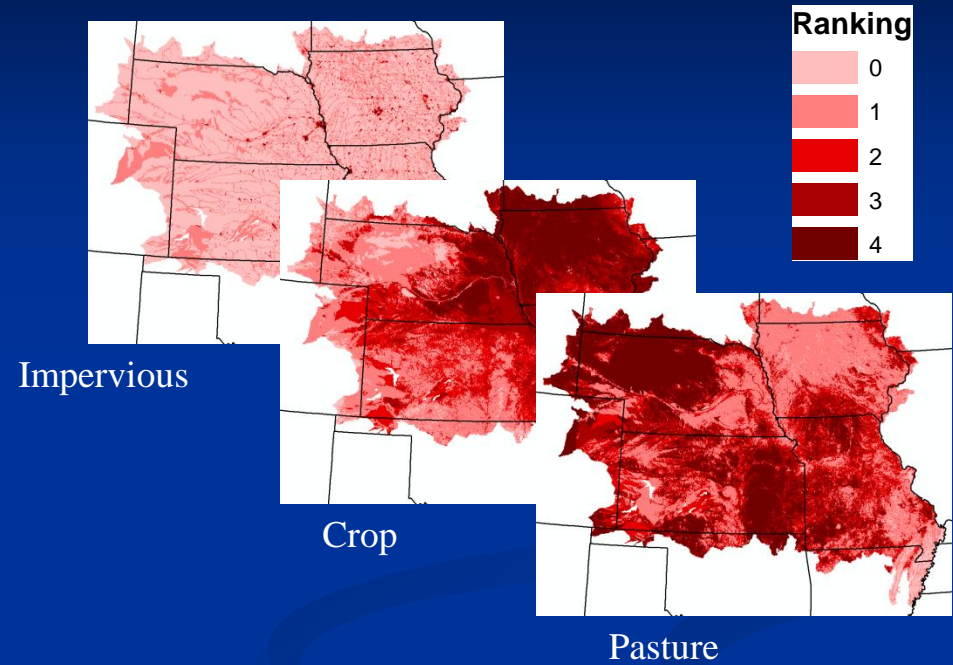
Individual Threat Classes

- Used five class ranking
 - 0 – 4
 - 0 usually reserved for “none”
 - Literature often used 4 or 5 classes



Ranking Individual Threats

- Used literature for
 - % Impervious
 - % Crop
 - % Pasture



Rank	% Impervious	% Crop	% Pasture
0	0	0	0
1	0 - 5	0 - 10	0 - 20
2	5 - 15	10 - 30	20 - 40
3	15 - 30	30 - 70	40 - 60
4	> 30	> 70	> 60

Ranking Individual Threats

- Most other threats – Percentile groups
- Zeros held out
- Number of classes?
- Class breaks vary by threat?
 - Prevalence on landscape determines rank

Rank	Percentile Group
0	No features
1	Less than 25 th
2	25 th – 50 th
3	50 th – 75 th
4	> 75 th

Ranking Individual Threats

Class Breaks Vary by Prevalence

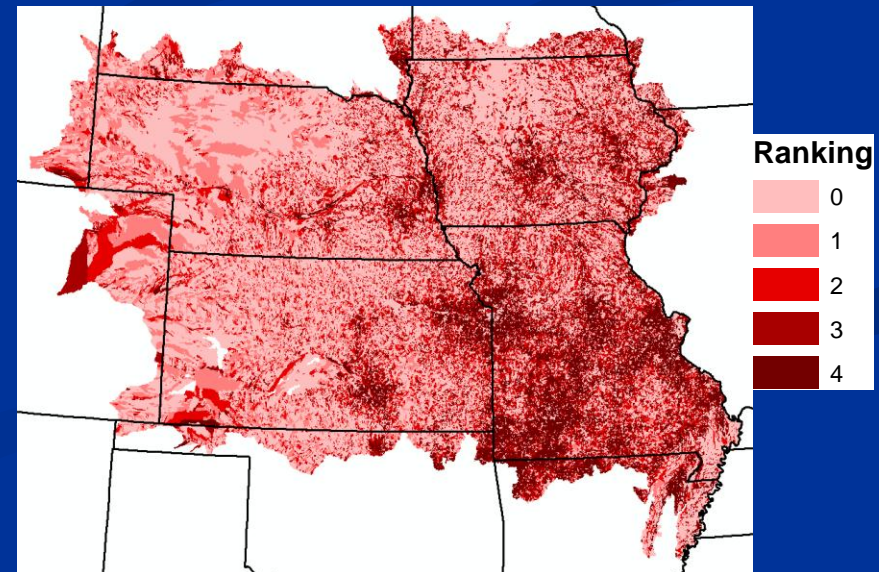
- Threat A
 - Density range 1 – 1000
 - Class 1 (low): 1 – 250
- Threat B
 - Density range 1 – 100
 - Class 1 (low): 1 – 25
- Threat B's class 4 (high) is compares to Threat A's class 1 (low)
- Is this something to avoid? Can we?

Things Ranked Differently

- Population change
 - Did not use “total population”
- Fragmentation from dams/impoundments
 - Various components

Population Change

- Population loss in watershed from 1990 – 2000
 - Considered “good”
 - Assigned rank of zero
- Positive population change
 - Percentile breaks
 - Ranks of 1 - 4



Fragmentation from Dams

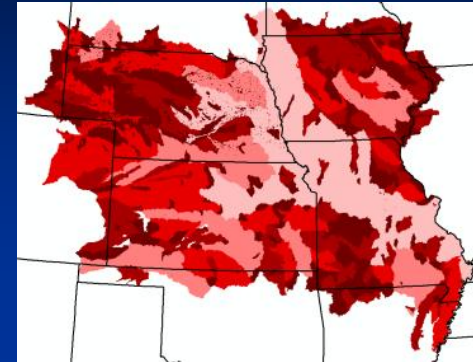
■ Two components considered

■ Fragment size

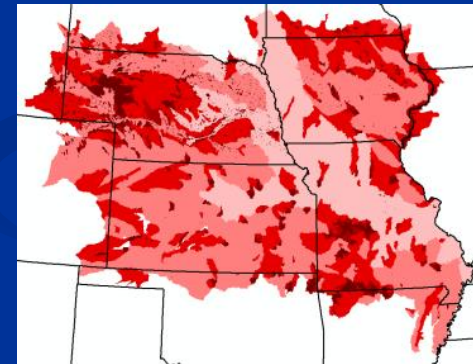
- Bigger is better

■ Number of stream sizes contained in each fragment

- More is better



Fragment
Size



Size
Classes in
Fragment

■ Also

■ Distance above lake

- Greater is better
- Inundated is worst

■ Distance below lake

Using Distance Weights for HTI

Distance Weighting

Step 1:

- Wanted to incorporate both Minimum and Average distance
- Created distance classes

Rank	Minimum Distance	Average Distance
15	0 - 2	0 - 2
7	2 - 10	2 - 10
3	10 - 100	10 - 100
1	> 100	> 100
0	None	None

Distance Weighting

Step 2:

- Density in watershed x Min rank x average rank
- Result ranked by percentiles; zeros held out

Mine Density (#/Km2)	Minimum Dist. Rank	Average Distance Rank	Distance weighted Score	Final Rank
0	0	0	0	0
0.03	3	1	0.09	1
0.03	7	3	0.63	2
0.03	3	15	1.35	3
0.03	15	15	6.75	4

Rank	Minimum Distance	Average Distance
15	0 - 2	0 - 2
7	2 - 10	2 - 10
3	10 - 100	10 - 100
1	> 100	> 100
0	None	None

Things not Distance Weighted

- Landcover (all classes)
- Pesticide application
- Linear features (roads, pipelines & rail roads)
- Population change
- Fragmentation from dams/impoundments
- Wells (too many to do)
- Headwater impoundments (too many)
- Road/stream crossings (too many)

Creating the “Index”

Methods and Discussion

Bringing it all Together

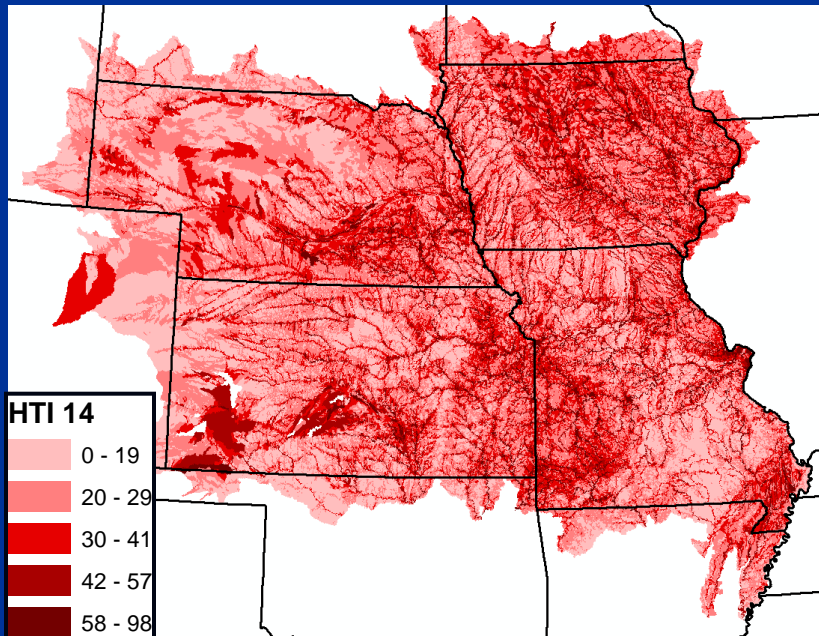
- Individual ranks are added together
- Result multiplied by mean rank and max rank
- Rescaled from 1 to 100

R	SUPER_R	TRI_R	WWTF_R	CAFO_R	LNDFIL_R	HPDES_R	RCRIS_R	POPDIF_R	CLASS_R	FRAGSZ_R	LKDIST_R	CNT_SIZE	HTI_14	MEAN_14	MAX_14	HTI_FULL	HTI_RESCAL
1	4	4	4	3	2	4	4	4	2	4	4	3	98	2.72	4	1067.11	100
1	4	4	3	3	3	4	4	4	2	4	4	3	98	2.72	4	1067.11	100
1	4	4	3	3	3	4	4	4	2	4	4	3	98	2.72	4	1067.11	100
1	4	4	3	3	3	4	4	4	2	4	4	3	98	2.72	4	1067.11	100
1	4	4	3	3	3	4	4	4	2	4	4	3	98	2.72	4	1067.11	100
1	4	4	4	2	3	4	4	4	2	4	4	3	98	2.72	4	1067.11	100
1	4	4	3	3	2	4	4	4	4	4	4	0	97	2.69	4	1045.44	97.97
1	4	4	3	3	2	4	4	4	2	4	4	3	97	2.69	4	1045.44	97.97
1	4	4	3	3	2	4	4	4	2	4	4	3	97	2.69	4	1045.44	97.97
1	4	4	3	2	2	4	4	4	4	4	4	0	96	2.67	4	1024	95.96
1	4	4	3	3	2	3	4	4	4	4	4	0	96	2.67	4	1024	95.96
1	4	4	3	2	2	4	4	4	4	4	4	0	96	2.67	4	1024	95.96
1	4	4	3	2	2	4	4	4	4	4	4	0	96	2.67	4	1024	95.96
1	4	4	4	1	3	3	4	4	2	4	4	3	96	2.67	4	1024	95.96
1	4	4	3	2	2	4	4	4	2	4	3	3	95	2.64	4	1002.78	93.97
1	4	4	3	2	2	4	4	4	2	4	3	3	95	2.64	4	1002.78	93.97
1	4	4	3	1	3	3	4	4	2	4	4	3	95	2.64	4	1002.78	93.97
1	4	4	3	1	3	3	4	4	2	4	4	3	95	2.64	4	1002.78	93.97
0	4	4	4	3	0	4	4	4	4	4	4	0	95	2.64	4	1002.78	93.97
0	4	4	3	2	0	4	4	4	4	4	4	0	94	2.61	4	981.78	92
0	4	4	3	3	3	4	4	4	1	3	3	4	93	2.58	4	961	90.06
0	4	4	3	3	3	4	4	4	1	3	3	4	93	2.58	4	961	90.06
1	4	3	3	2	2	4	3	4	4	4	4	0	93	2.58	4	961	90.06

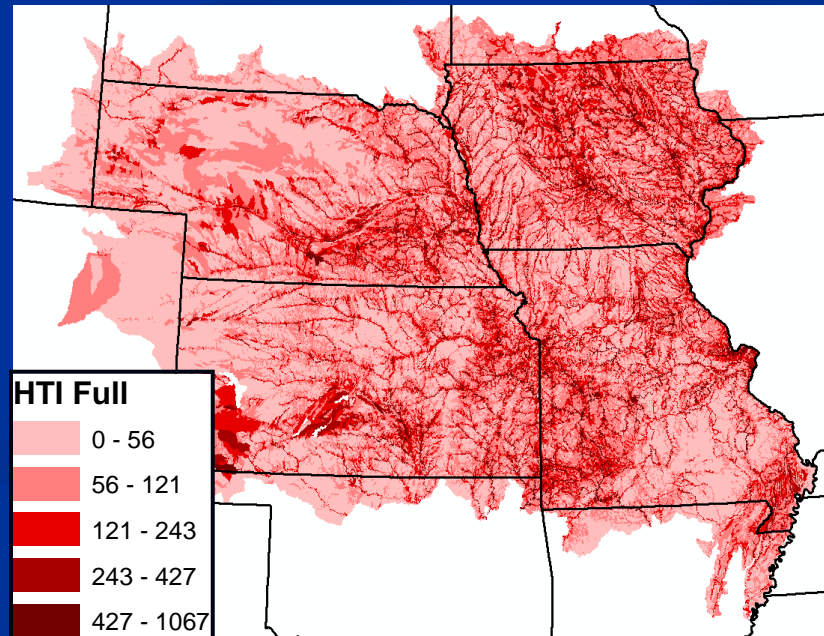
Raw HTI

R	SUPER_R	TRI_R	WWTF_R	CAFO_R	LNDFIL_R	NPDES_R	RCRIS_R	POPDIF_R	CLASS_R	FRAGSZ_R	LKDIST_R	CNT_SIZE	HTI_14	MEAN_14	MAX_14	HTI_FULL	HTI_RESCAL
1	4	4	4	3	2	4	4	4	2	4	4		98	2.72	4	1067.11	100
1	4	4	3	3	3	4	4	4	2	4	4		98	2.72	4	1067.11	100
1	4	4	3	3	3	4	4	4	2	4	4		98	2.72	4	1067.11	100
1	4	4	3	3	3	4	4	4	2	4	4		98	2.72	4	1067.11	100
1	4	4	3	3	3	4	4	4	2	4	4		98	2.72	4	1067.11	100
1	4	4	4	2	3	4	4	4	2	4	4		98	2.72	4	1067.11	100
1	4	4	3	3	2	4	4	4	4	4	4		97	2.69	4	1045.44	97.97
1	4	4	3	3	2	4	4	4	2	4	4		97	2.69	4	1045.44	97.97
1	4	4	3	3	2	4	4	4	2	4	4		97	2.69	4	1045.44	97.97
1	4	4	3	2	2	4	4	4	4	4	4		96	2.67	4	1024	95.96
1	4	4	3	3	2	3	4	4	4	4	4		96	2.67	4	1024	95.96
1	4	4	3	2	2	4	4	4	4	4	4		96	2.67	4	1024	95.96
1	4	4	3	2	2	4	4	4	4	4	4		96	2.67	4	1024	95.96
1	4	4	4	1	3	3	4	4	2	4	4		96	2.67	4	1024	95.96
1	4	4	3	2	2	4	4	4	2	4	3		95	2.64	4	1002.78	93.97
1	4	4	3	2	2	4	4	4	2	4	3		95	2.64	4	1002.78	93.97
1	4	4	3	1	3	3	4	4	2	4	4		95	2.64	4	1002.78	93.97

Individual Threat Ranks Summed

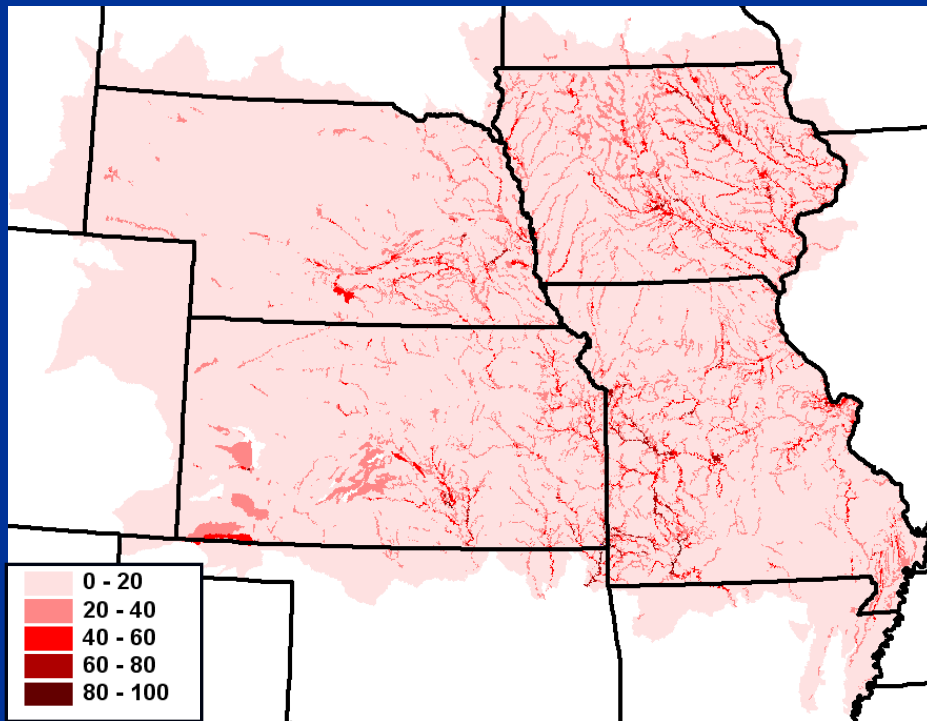


... And multiplied by mean & max

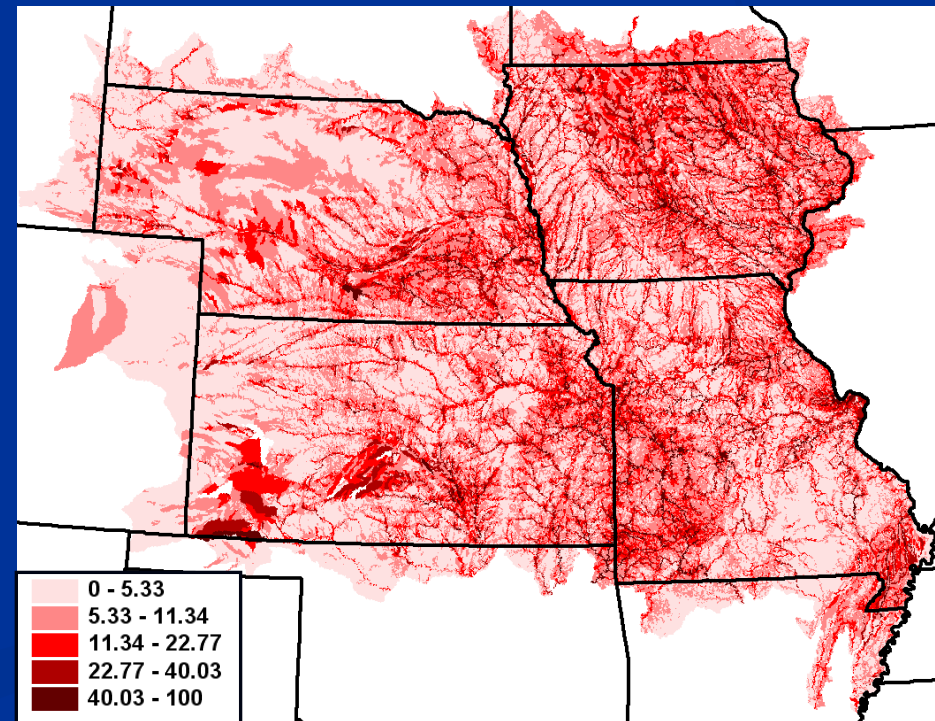


HTI Different Perspectives

R	SUPER_R	TRI_R	WWTF_R	CAFO_R	LNDFIL_R	NPDES_R	RCRIS_R	POPDIF_R	CLASS_R	FRAGSZ_R	LKDIST_R	CNT_SIZE	HTI_14	MEAN_14	MAX_14	HTI_FULL	HTI_RESCAL
1	4	4	4	3	2	4	4	4	2	4	4	3	98	2.72	4	1067.1	100
1	4	4	3	3	3	4	4	4	2	4	4	3	98	2.72	4	1067.1	100
1	4	4	3	3	3	4	4	4	2	4	4	3	98	2.72	4	1067.1	100
1	4	4	3	3	3	4	4	4	2	4	4	3	98	2.72	4	1067.1	100
1	4	4	3	3	3	4	4	4	2	4	4	3	98	2.72	4	1067.1	100
1	4	4	4	2	3	4	4	4	2	4	4	3	98	2.72	4	1067.1	100
1	4	4	3	3	2	4	4	4	4	4	4	0	97	2.69	4	1045.4	97.97
1	4	4	3	3	2	4	4	4	2	4	4	3	97	2.69	4	1045.4	97.97
1	4	4	3	3	2	4	4	4	2	4	4	3	97	2.69	4	1045.4	97.97
1	4	4	3	2	2	4	4	4	4	4	4	0	96	2.67	4	102	95.96
1	4	4	3	3	2	3	4	4	4	4	4	0	96	2.67	4	102	95.96
1	4	4	3	2	2	4	4	4	4	4	4	0	96	2.67	4	102	95.96
1	4	4	3	2	2	4	4	4	4	4	4	0	96	2.67	4	102	95.96
1	4	4	4	1	3	3	4	4	2	4	4	3	96	2.67	4	102	95.96
1	4	4	3	2	2	4	4	4	2	4	3	3	95	2.64	4	1002.7	93.97
1	4	4	3	2	2	4	4	4	2	4	3	3	95	2.64	4	1002.7	93.97

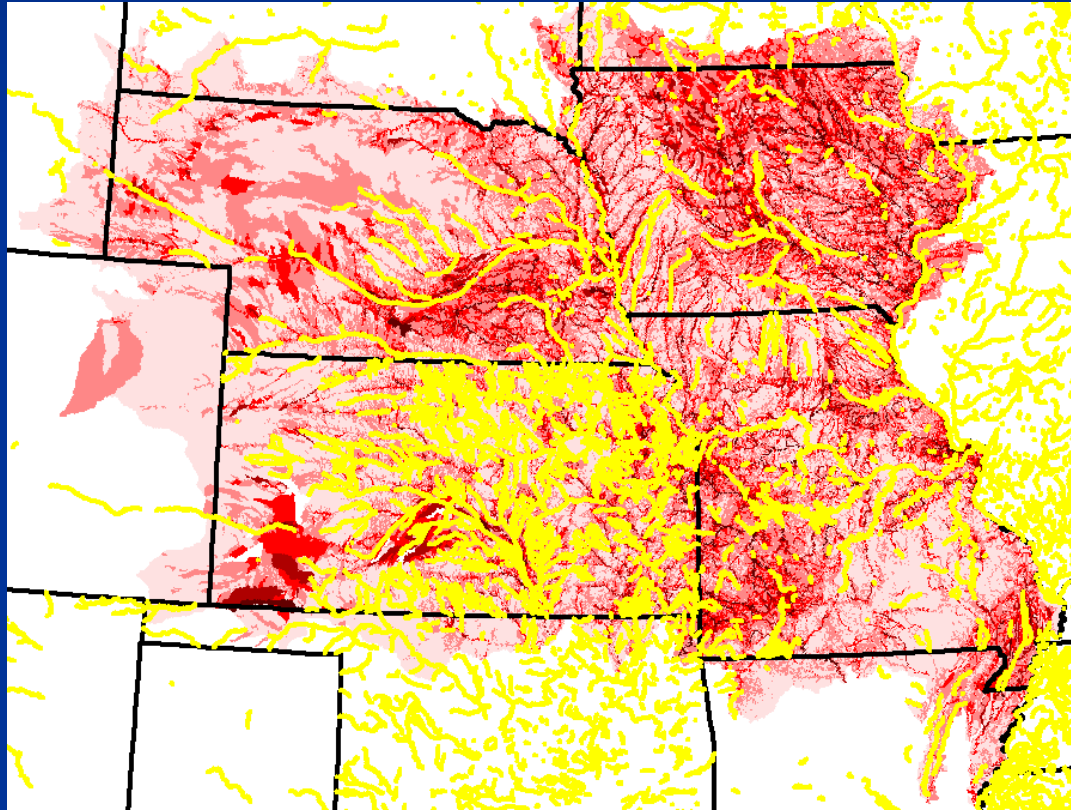


Equal Interval



Natural Breaks

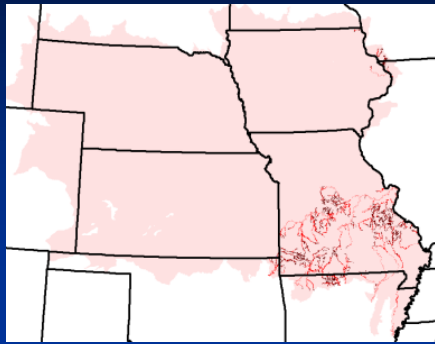
HTI and 303d (2002)



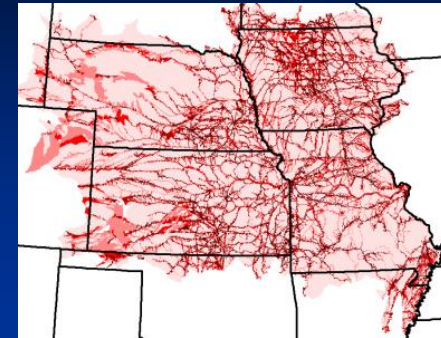
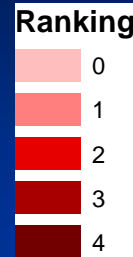
HTI Discussion

- What should index represent?
 - Degree of threat?
 - Degree of impairment?
 - Probability of impairment?
- Some threats are rare and random (i.e. pipelines)
- Others are persistent (i.e. impervious surface)
- We have these things integrated in the current index
- For example, could have a high number of rare random threats that lead to a high (bad) index, yet stream is high quality

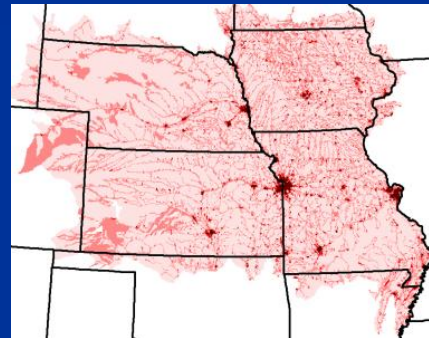
HTI Discussion



Lead



Rail lines



Impervious

- Can we get closer to measuring degree of impairment?
- To do so we must be able to compare across threats
 - I.e., a “4” for one threat is defined the same as a “4” for another threat
 - Does a single “4” mean the stream should be trashed?

HTI Discussion

Some Observations

- Weighting among threats
 - Urban areas don't stand out while reservoirs do
- Mainstems
 - Number of threats influences overall HTI
 - Most threats are found somewhere upstream
- The HTI is more influenced by the number of threats rather than individual magnitude
 - One or two very bad threats could result in a low HTI

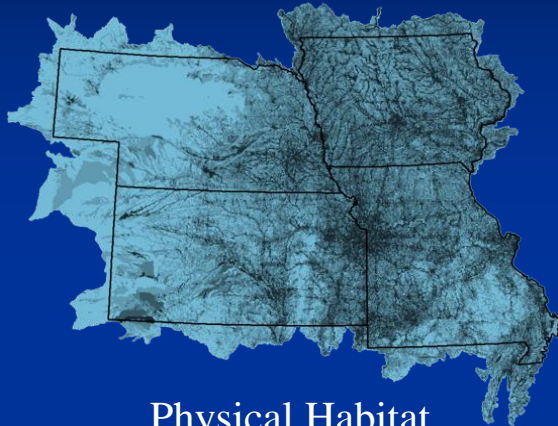
HTI Discussion

- Options for getting closer to measuring impairment
 - Use weighting criteria from “survey of professionals”
 - Make all values relative to highest value
 - More distance restrictions for some threats
 - Quantify threats to more directly relate to stressors
 - For example, quantify area behind impoundments differently

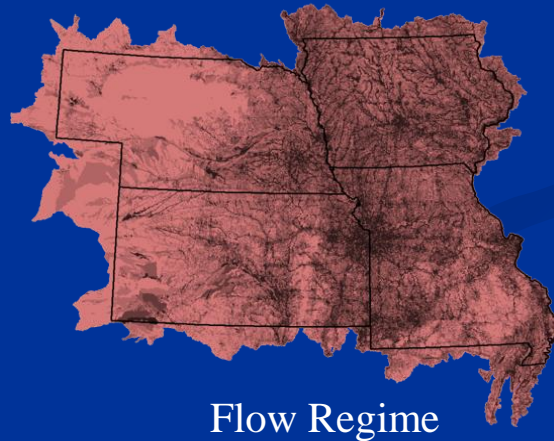
HTI Discussion

- Bottom line:
 - We would like to get closer to measuring “impairment”
 - Continue investigating ways to create meaningful HTI

Separate Human Threat Index for Components of Ecological Integrity



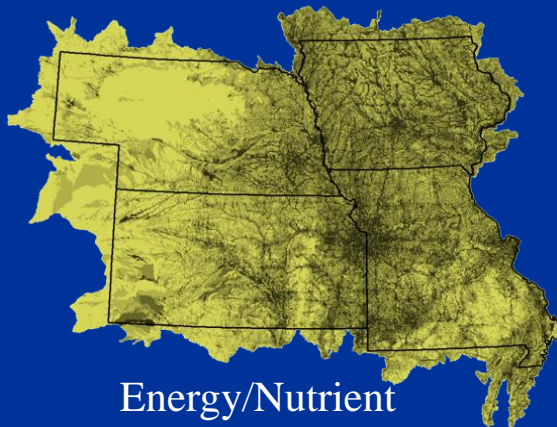
Physical Habitat



Flow Regime



Water Quality



Energy/Nutrient
Dynamics



Biotic Interactions

Developing Separate Indices

	A	B	C	D	E
1	Threats	Physical	Habitat		Key
2		Mean	Mode		0 = No Impact
3	Channelization	3.0	3		1 = Low Impact
4	Instream Sand And Gravel Mines	2.9	3		2 = Moderate Impact
5	Major Reservoirs	2.8	3		3 = High Impact

	A	B	C	D	E
6	Navigation (Channel and Bank Maintenance)	Threats	Water Quality		Key
7	Row Crop Agriculture		Mean	Mode	0 = No Impact
8	Impervious Surface		2.8	3	1 = Low Impact
9	Headwater Impoundments (Impoundments on Second-Order and Smaller Streams)				2 = Moderate Impact

	A	B	C	D	E
10	Introduced Plants	Flow Regime			Key
11	Water Withdrawals		Mean	Mode	0 = No Impact
12	Roads (Paved And Gravel)		2.8	3	1 = Low Impact
13	Flow Diversions (No Return Flow)				

	A	B	C	D	E
14	Dispersal Barriers / Low Head Dams	Threats	Energy / Nutrient		Key
15	Artificial Drainage (Agricultural Field Drainage)		Mean	Mode	0 = No Impact
16	Military Sites (With Regard to Land Disturbance)		2.6	3	1 = Low Impact
17	Flow Diversions (With Return Flow)				

	A	B	C	D	E
18	Road-Stream Crossing (Culverts And Low-Water)	Threats	Energy / Nutrient		Key
19	Upland Mining		Mean	Mode	0 = No Impact
20	Ranging Livestock		2.6	3	1 = Low Impact
21	Storm Water Systems				

	A	B	C	D	E
22	Bridges	Threats	Energy / Nutrient		Key
23	CAFO		Mean	Mode	0 = No Impact
24	Golf Course		2.6	3	1 = Low Impact
25	Point Source Discharges (NPDES: Municipal, Agricultural, And Industrial)				

	A	B	C	D	E
26	Landfills	Threats	Energy / Nutrient		Key
27			Mean	Mode	0 = No Impact
28			2.6	3	1 = Low Impact
29					

	A	B	C	D	E
30		Threats	Energy / Nutrient		Key
31			Mean	Mode	0 = No Impact
32			2.6	3	1 = Low Impact
33					

	A	B	C	D	E
34		Threats	Energy / Nutrient		Key
35			Mean	Mode	0 = No Impact
36			2.6	3	1 = Low Impact
37					

	A	B	C	D	E
38		Threats	Energy / Nutrient		Key
39			Mean	Mode	0 = No Impact
40			2.6	3	1 = Low Impact
41					

	A	B	C	D	E
42		Threats	Energy / Nutrient		Key
43			Mean	Mode	0 = No Impact
44			2.6	3	1 = Low Impact
45					

	A	B	C	D	E
46		Threats	Energy / Nutrient		Key
47			Mean	Mode	0 = No Impact
48			2.6	3	1 = Low Impact
49					

	A	B	C	D	E
50		Threats	Energy / Nutrient		Key
51			Mean	Mode	0 = No Impact
52			2.6	3	1 = Low Impact
53					

Principal Ecological Effects

	Point source pollution				
Level of Influence	Physical Habitat	Water Quality	Flow Regime	Energy/Nutrient	Biotic Interactions
Low	X		X		
Medium					
High		X		X	X

	A	B	C	D	E
1	Threats	Biotic Interactions			Key
2		Mean	Mode		0 = No Impact
3	Introduced Aquatic Animals	2.9	3		1 = Low Impact
4	Major Reservoirs	2.8	3		2 = Moderate Impact
5	Introduced Plants	2.6	3		3 = High Impact
6	Headwater Impoundments (Impoundments on Second-Order and Smaller Streams)	2.4	3		
7	Channelization	2.3	3		
8	Dispersal Barriers / Low Head Dams	2.3	3		
9	Waste Water Treatment Facility	2.2	2,3		
10	Point Source Discharges (NPDES: Municipal, Agricultural, And Industrial)	2.1	3		
11	Row Crop Agriculture	2.0	1,3		
12	Instream Sand And Gravel Mines	2.0	2,3		
13	CAFO	1.9	1		
14	Navigation (Channel and Bank Maintenance)	1.8	1		
15	Toxic Releases	1.8	3		
16	Water Withdrawals	1.8	2		
17	Artificial Drainage (Agricultural Field Drainage)	1.8	1		
18	Road-Stream Crossing (Culverts And Low-Water)	1.8	2		
19	Impervious Surface	1.7	2		
20	Roads (Paved And Gravel)	1.7	2		
21	Flow Diversions (With Return Flow)	1.7	1,2		
22	Storm Water Systems	1.6	2		
23	Flow Diversions (No Return Flow)	1.6	2		
24	Golf Course	1.5	1		
25	Upland Mining	1.4			
26	Ranging Livestock	1.4	1		

Thanks



Environmental Protection Agency



Missouri
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